New Nouveau
Brunswick

Information Circular 90-2

Project Summaries for 1990

Fifteenth Annual Review of Activities

Compiled and Edited by

Shasta A. Abbott

Natural Resources and Energy

Mineral Resources

Information Circular 90-2

Project Summaries for 1990

Fifteenth Annual Review of Activities

This report has been prepared by:

Mineral Resources
Department of Natural Resources and Energy
Province of New Brunswick

Hon. Morris Green
Minister of Natural Resources and Energy

Hon. Edmond Blanchard
Minister of State for Mines

1990

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Price $11.10

91-05446/

This report should be referenced in the following manner:

ABBOTT, S.A. (editor) 1990. Project summaries for 1990, Fifteenth Annual Review of Activities. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Information Circular 90-2, 214 p.

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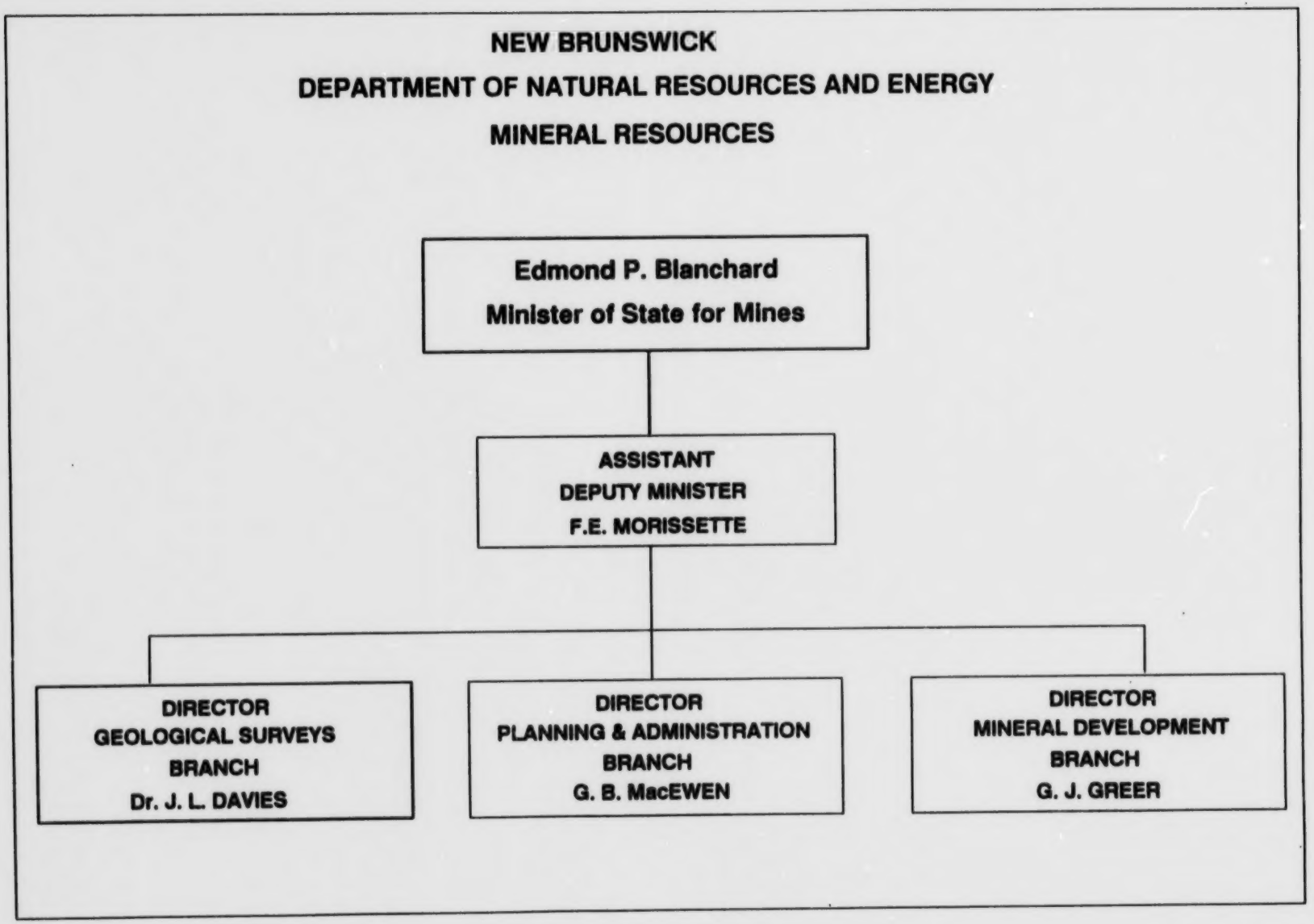
ACKNOWLEDGEMENTS

Special thanks to Les Fyffe for his technical advice and editorial criticism; to Jacques Thibault for helping with last-minute changes to résumés; to Kim O'Donnell for reformatting project summaries; and to Diane Blair for checking references. Abstracts were translated by the Translation Bureau. Gerry Johnson, Terry Leonard, Maurice Mazerolle, and André LeBlanc drafted most of the figures. Michael Côté, of Communications New Brunswick, designed the cover using the current New Brunswick logo. The staff of the Communications Design Centre provided photographic services.

NOTES

PART I

MINERAL RESOURCES DIVISION



General organization chart for Mineral Resources Division

ORGANIZATION OF THE MINERAL RESOURCES DIVISION

INTRODUCTION

New Brunswick has traditional responsibilities for mineral resources it owns and controls. The Mineral Resources Division manages, via a number of Acts, all matters related to mineral exploration, mine development, mineral processing and mine reclamation. The Division promotes the mineral resource potential of the Province and encourages exploration and mining. However, it strongly supports an attainment of a balance between the preservation of the environment and economic development.

The Division comprises three branches: Geological Surveys, Mineral Development, and Planning and Administration. The clientele are primarily mineral resource companies, but geoscience information generated by staff is extremely important to sound management of forest, water, and land resources.

GEOLOGICAL SURVEYS BRANCH (Director, J. Leslie Davies)

The Geological Surveys Branch is responsible for the collection, interpretation, dissemination, and management of geoscience data in New Brunswick. The Branch goals are to decipher the regolith and bedrock framework of the Province, and to identify the mineral resource potential of the various geological terranes. Closely related activities include; encouraging mineral exploration, promotion of the mineral industry, and advising government on management of mineral, water, and land resources.

The Provincial 'A' budget for 1990/91 is $1.42 million, up slightly from 1989/90. The Canada-New Brunswick Mineral Development Agreement (MDA I) terminated on March 31, 1990. The new Canada-New Brunswick Cooperative Agreement on Mineral Development (MDA II), under negotiation for over two years, was signed in September, 1990. Provincial projects included in this agreement have been underway since April, 1990.

MINERAL DEVELOPMENT BRANCH (Director, George Greer)

The Mineral Development Branch is responsible for all activities related to the allocation of mineral rights under the Mining Act and the Quarriable Substances Act; for the utilization of the minerals and quarriable substances in accordance to maximum extraction techniques both in mining and beneficiation; and for the proper reclamation of the disturbed lands. These activities include monitoring the prospecting, exploration, and development stages of the resources as well as reviewing production plans, reclamation plans, and promoting further processing of minerals within the Province. The Branch administers the following Acts: Mining Act, Quarriable Substances Act, Ownership of Minerals Act, and the Metallic Minerals Tax Act. In addition, the Branch is responsible for acting on decisions under the Peat Policy, Potash Policy, and Coal Policy.

PLANNING AND ADMINISTRATION BRANCH (Director, Garry MacEwen)

The Planning and Administration Branch is responsible for providing the economic and financial analysis to develop mineral resource management policies and programs; evaluating federal and other provincial government policies and programmes that affect the management of mineral resources; co-ordinating the development and administration of federal/provincial mineral development agreements; coordinating legislative, regulatory, and programme initiatives that the Department wishes to carry forward to the Legislature; coordinating geoscientific information and events for public and industry consumption; and providing administrative support to the Mineral Resources Division regarding budgets, staff, and financial information.

ORGANISATION DE LA DIVISION DES RESSOURCES MINÉRALES

INTRODUCTION

Le Nouveau-Brunswick a des responsabilités traditionnelles sur les ressources minérales qu'il possède et contrôle. La Division des ressources minérales gère, par l'entremise d'une série de lois, tout ce qui concerne l'exploration minérale, l'exploitation des mines, la minéralurgie, et le réaménagement des mines. La Division promouvoit le potentiel des ressources minérales de la province et encourage l'exploration et l'exploitation. Toutefois, une importance particulière est accordée à l'atteinte d'un équilibre entre la préservation de l'environnement et le développement économique.

La Division comprend trois directions : les études géologiques, le développement minier, la planification et l'administration. La clientèle est principalement composée de compagnies minières, mais l'information générée par le personnel est extrêmement importante pour une saine gestion des ressources en eau, en terres et en forêts.

DIRECTION DES ÉTUDES GÉOLOGIQUES
(J. Leslie Davies, directeur)

La direction des études géologiques est responsable de la cueillette, de l'interprétation, de la dissémination, et de la gestion des données géoscientifiques du Nouveau-Brunswick. Les buts de la direction sont d'éclaircir l'ensemble régolithique et la structure du socle rocheux de la province, et d'identifier le potentiel minier des différentes formations géologiques. Les activités connexes comprennent : encourager l'exploration minérale, promouvoir l'industrie minière, et conseiller le gouvernement sur la gestion des ressources minières, hydriques et en terres.

Le budget 'A' provincial pour 1990-1991 est de 1,420,000 $, soit une légère augmentation par rapport à 1989-1990. L'Entente Canada - Nouveau-Brunswick de développement minier (EDM I) s'est terminée le 31 mars 1990. La nouvelle Entente de coopération Canada - Nouveau-Brunswick sur le développement minier (EDM II), en négociation depuis plus de deux ans, a été signée en septembre 1990. Les projets provinciaux inclus dans cette entente sont en marche depuis avril 1990.

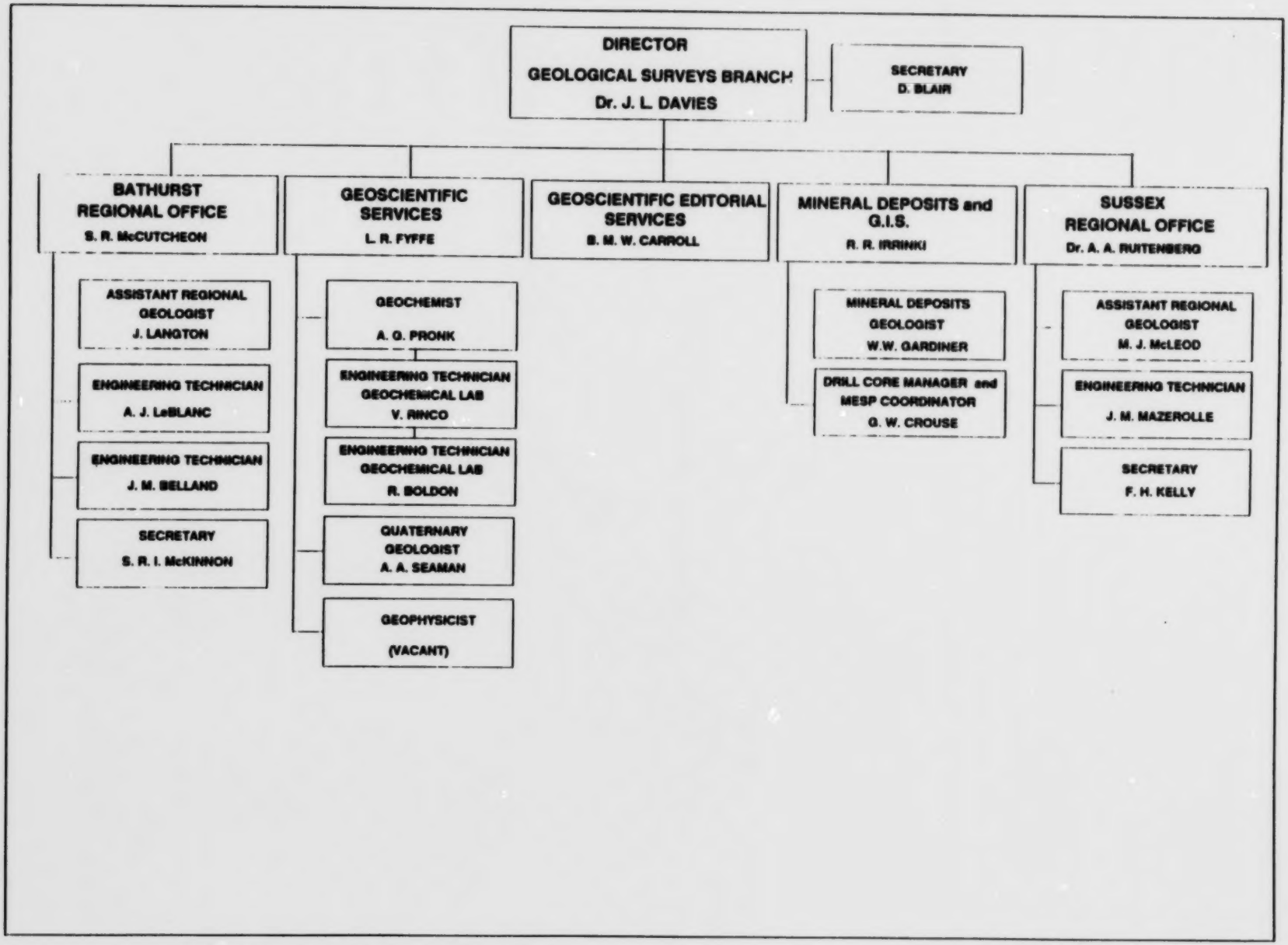
DIRECTION DE L'EXPLOITATION DES RESSOURCES MINIÈRES
(George Greer, directeur)

La direction de l'exploitation des ressources minières est responsable de toutes les activités se rattachant à l'allocation des droits miniers qui relèvent de la Loi sur les mines et de la Loi sur l'exploitation des carrières; de l'utilisation des minéraux et du matériel exploité en carrière selon des techniques d'extraction maximales, tant en exploitation qu'en valorisation; et de la restauration adéquate des terrains perturbés. Ces activités incluent la surveillance des ressources au niveau des étapes de prospection, d'exploration et d'exploitation, de même que la révision des plans de production et des plans de réaménagement, et la promotion du traitement de plus grandes quantités de minerais à l'intérieur de la province. La direction administre les lois suivantes : la Loi sur les mines, la Loi sur l'exploitation des carrières, la Loi sur la propriété de minéraux, et la Loi de la taxe sur les minéraux métalliques. De plus, la section est responsable de l'application des décisions relevant de la politique sur les tourbes, de la politique sur la potasse, et de la politique sur le charbon.

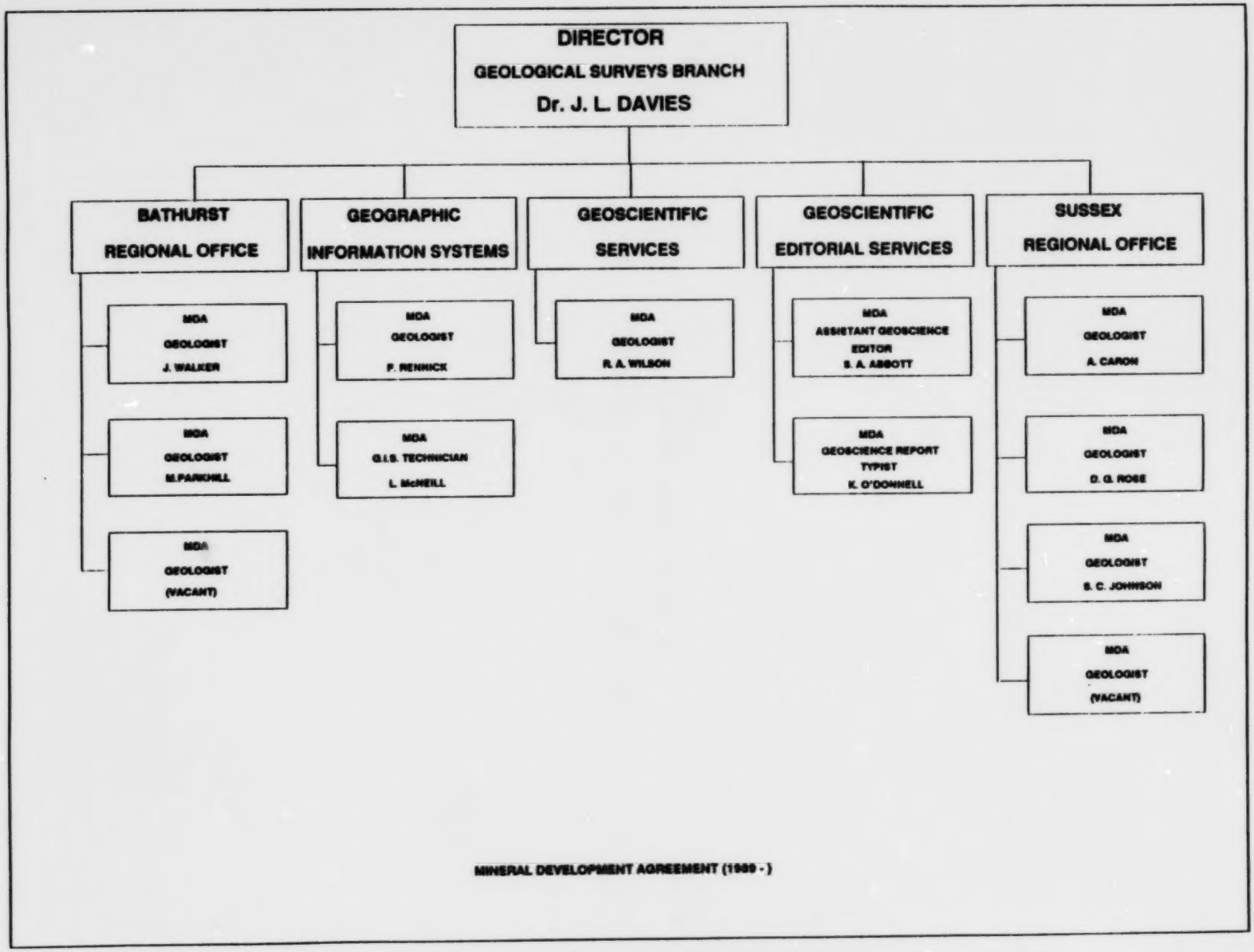
DIRECTION DE LA PLANIFICATION ET DE L'ADMINISTRATION
(Garry MacEwen, directeur)

La direction de la planification et de l'administration est responsable de fournir l'analyse économique et financière servant à développer les politiques et programmes de gestion des ressources minières; d'évaluer les politiques et programmes fédéraux et provinciaux qui affectent la gestion des ressources minières; de coordonner le développement et l'administration des ententes de développement fédérales-provinciales; de coordonner les initiatives en matière de législations, de réglementations, et de programmes que le ministère a l'intention de soumettre au corps législatif; de coordonner l'information géoscientifique et les événements d'intérêt public et industriel; et de fournir un support administratif à la Division des ressources minières en ce qui a trait aux budgets, au personnel, et à l'information financière.

GEOLOGICAL SURVEYS BRANCH



Organization chart for Geological Surveys Branch - permanent staff



Organization chart for Geological Surveys Branch - MDA contract personnel

GEOLOGICAL SURVEYS BRANCH

GEOSCIENTIFIC SERVICES SECTION

ACTIVITIES OF THE GEOSCIENTIFIC SERVICES SECTION

L.R. Fyffe, Senior Geologist

The Geoscientific Services staff, located at the Hugh John Flemming Centre in Fredericton, consists of Les Fyffe (Senior Geologist), Allen Seaman (Quaternary Geologist), Toon Pronk (Geochemist), Valeria Rinco (Geochemical Analyst), and Rex Boldon (technician). Reg Wilson (Project Geologist) carried out a contract mapping project under the Canada-New Brunswick Mineral Development Agreement (MDA).

Les Fyffe is mapping the bedrock geology in the St. Stephen area (NTS 21 G/3) of southern New Brunswick on a 1:20 000 scale in order to review the stratigraphy of the Cookson Group. Reg Wilson is studying the relationship between volcanic environment and mineralization in the California Lake (NTS 21 O/8) map area of northern New Brunswick. Allen Seaman and Toon Pronk are carrying out surficial mapping and till and silt sampling surveys over the southern Pokiok Batholith in western New Brunswick.

Reports have been published on the geology and geochemistry of the Burnthill area (Mineral Resource Report 4 by MacLellan, Taylor, and Gardiner) and New Denmark-Salmon River area (Report of Investigation 23 by R. Wilson). These reports, together with several articles published in various scientific journals, finalizes the results of geological projects carried out by the Fredericton office under the Canada-New Brunswick Mineral Development Agreement (1984-89).

A paper on volcanic geochemistry and massive sulphide deposits in the northeastern Appalachians by Fyffe, van Staal, and Winchester was published in the CIM Bulletin. Toon Pronk and Allen Seaman attended a meeting of the American and Canadian Quaternary associations in Waterloo, where they presented papers on the glacial history of the northern Miramichi Highlands and of southwestern New Brunswick, respectively.

ACTIVITÉS DE LA SECTION DES SERVICES GEOSCIENTIFIQUES

L.R. Fyffe, géologue senior

Le personnel de la section des services géoscientifiques travaille au centre Hugh John Flemming à Fredericton, et se compose de Les Fyffe (géologue sénior), Allen Seaman (géologue du quaternaire), Toon Pronk (géochimiste), Valeria Rinco (analyste en géochimie) et Rex Boldon (technicien). Reg Wilson (géologue de projet) a réalisé un projet de cartographie à contrat aux termes de l'Entente Canada - Nouveau-Brunswick.

Les Fyffe a cartographié la géologie de la région de St. Stephen (SNRC 21 G/3) au sud du Nouveau-Brunswick à l'échelle de 1:20 000, de façon à réexaminer la stratigraphie du groupe de Cookson. Reg Wilson étudie le lien entre le milieu volcanique et la minéralisation dans la région du lac Californie (NTS 21 O/8) au nord du Nouveau-Brunswick. Allen Seaman et Toon Pronk effectuent la cartographie des dépôts meubles, ainsi que des levés d'échantillonnage du till et du silt au-dessus du batholite sud de Pokiok dans la partie ouest du Nouveau-Brunswick.

Des rapports ont été publiés sur la géologie et la géochimie de la région de Burnthill (rapport n° 4 sur les ressources minérales par MacLellan, Taylor et Gardiner) et de la région de la rivière New Denmark-Salmon (rapport d'investigation n° 23 par R. Wilson). Ces rapports, de même que plusieurs articles publiés dans diverses revues scientifiques, complètent les résultats des projets géologiques exécutés par le bureau de Fredericton en vertu de l'Entente de développement minier Canada - Nouveau-Brunswick (1984-1989).

Un article portant sur la géochimie volcanique et les gisements de sulfures massifs dans la région du nord-est des Appalaches par Fyffe, van Staal et Winchester a été publié dans le bulletin de l'ICM. Toon Pronk et Allen Seaman ont assisté à une rencontre de l'Association canadienne et américaine pour l'étude du quaternaire tenue à Waterloo, où ils présentèrent des exposés qui portaient respectivement sur l'historique de la glaciation de la partie nord des hautes terres de Miramichi et de la partie sud du Nouveau-Brunswick.

HALFMILE - HEATH STEELE PROJECT, NORTHUMBERLAND COUNTY, NEW BRUNSWICK (MDA)

R.A. Wilson, Project Geologist

A stratigraphic study of the Tetagouche Group in the California Lake map area is being conducted in order to establish the relationships between depositional environment and mineralization.

Several volcanic facies have been recognized in the eastern part of the area during the initial stage of the investigation. These facies include aphyric, feldspar-phyric, quartz-phyric and nodular spherulitic rhyolites, and quartz-feldspar porphyry. The absence of pumice fragments and broken crystals indicate pyroclastic rocks are uncommon probably due to deposition in a subaqueous environment. The feldspar-phyric and spherulitic facies are interpreted to represent flows in the vicinity of volcanic domes.

Une étude stratigraphique du groupe de Tétagouche dans la région de la carte de California Lake est en cours afin d'établir les liens qui existent entre le milieu de formation et la minéralisation.

Plusieurs faciès volcaniques ont été identifiés dans la partie est de la zone durant l'investigation initiale. Ces faciès comprennent des rhyolites aphanitiques, à feldspath et à quartz phyriques et à nodules sphérolitiques, et des porphyres de quartz feldspathique. L'absence de fragments de pierre ponce et de cristaux brisés indiquent que les roches pyroclastiques sont peu communes, probablement à cause de la formation en milieu subaquatique. Les faciès de feldspath phyrique et sphérolitiques s'interprètent comme des coulées à proximité de dômes volcaniques.

A study of the volcanic stratigraphy of a portion of the Bathurst-Newcastle mining camp was undertaken in 1990. The objectives are (1) to establish the context of mineralization within the volcano-sedimentary framework of the Tetagouche Group, and (2) to identify any variation in the environment or style of volcanism between the western (Halfmile Lake) and eastern (Heath Steele) portions of the survey area. Interpretation of volcanic facies present in the respective areas, in conjunction with structural studies, should help to explain the relative scarcity of mineral occurrences in the southwest portion of the Bathurst camp compared to the northeast, and to facilitate the search for additional mineral deposits in the former area.

Initial field work has been concentrated on the Heath Steele-Nepisiguit River area, where relatively good exposure should permit interpretation of the stratigraphy. Mapping has been carried out at 1:10 000 scale in the southeast quadrant of the California Lake map area (NTS 21 O/8; Figure 1). To date, nearly 1800 outcrops have been mapped, and about 1200 rock samples collected. A number of samples have been selected for thin-section preparation, but petrographic studies have not

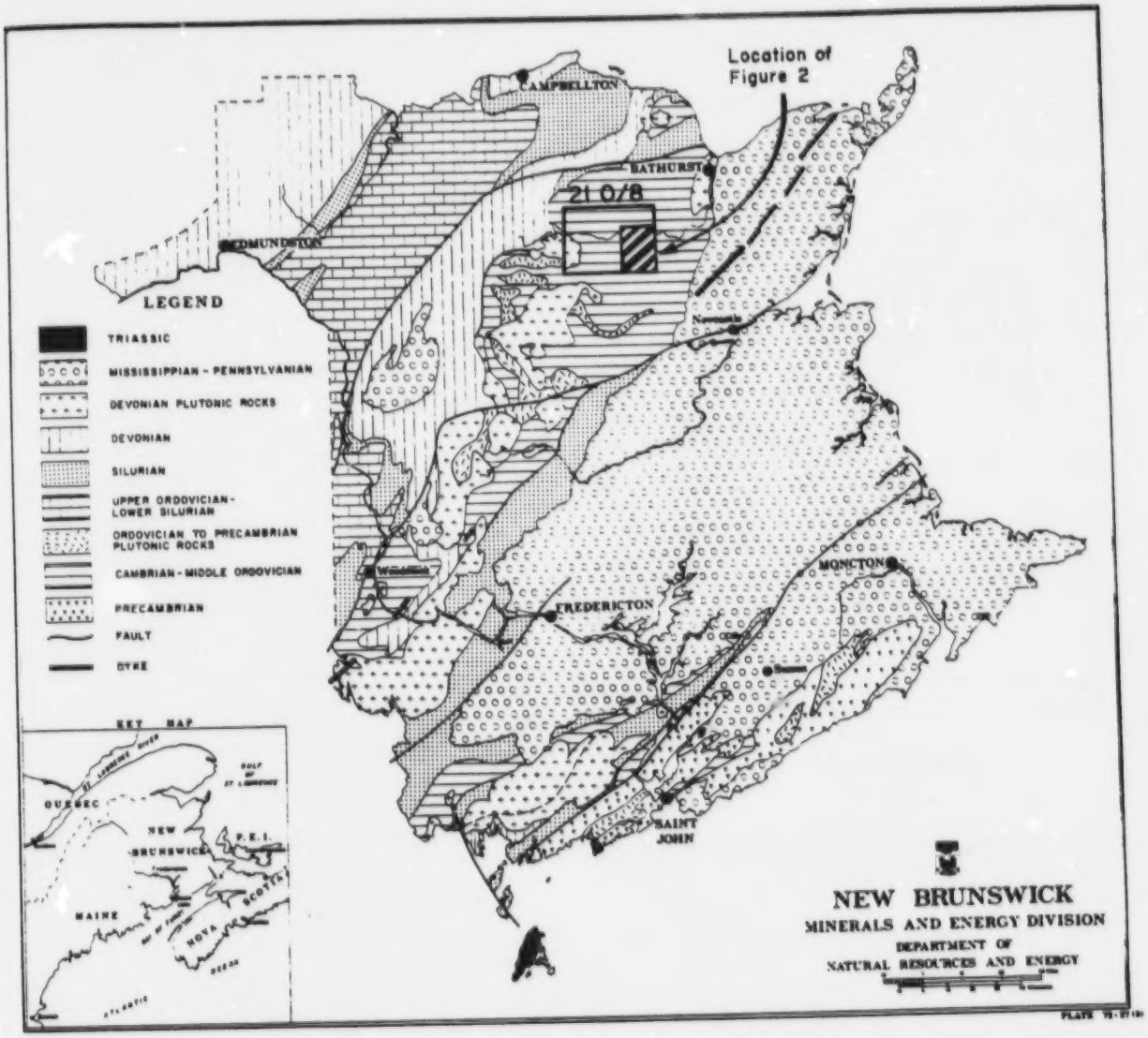


FIGURE 1. Location map for the Heath Steele-Nepisiguit River project.

begun as yet. Samples will also be submitted for whole-rock and trace-element analyses.

Felsic volcanic rocks underlie about 80% of the project area (Figure 2). Most of these rocks are aphyric to feldspar-, or locally, quartz-phyric aphanitic rhyolite, felsic schist, and metarhyolite, commonly well foliated, and sericite- or chlorite-rich. An original glassy state is inferred for most of these rocks, based on local spherulitic textures and a characteristic mottled appearance due to devitrification. Microfracturing due to volume change during devitrification increased the permeability of many of these rocks to circulating fluids, leading to widespread chloritization.

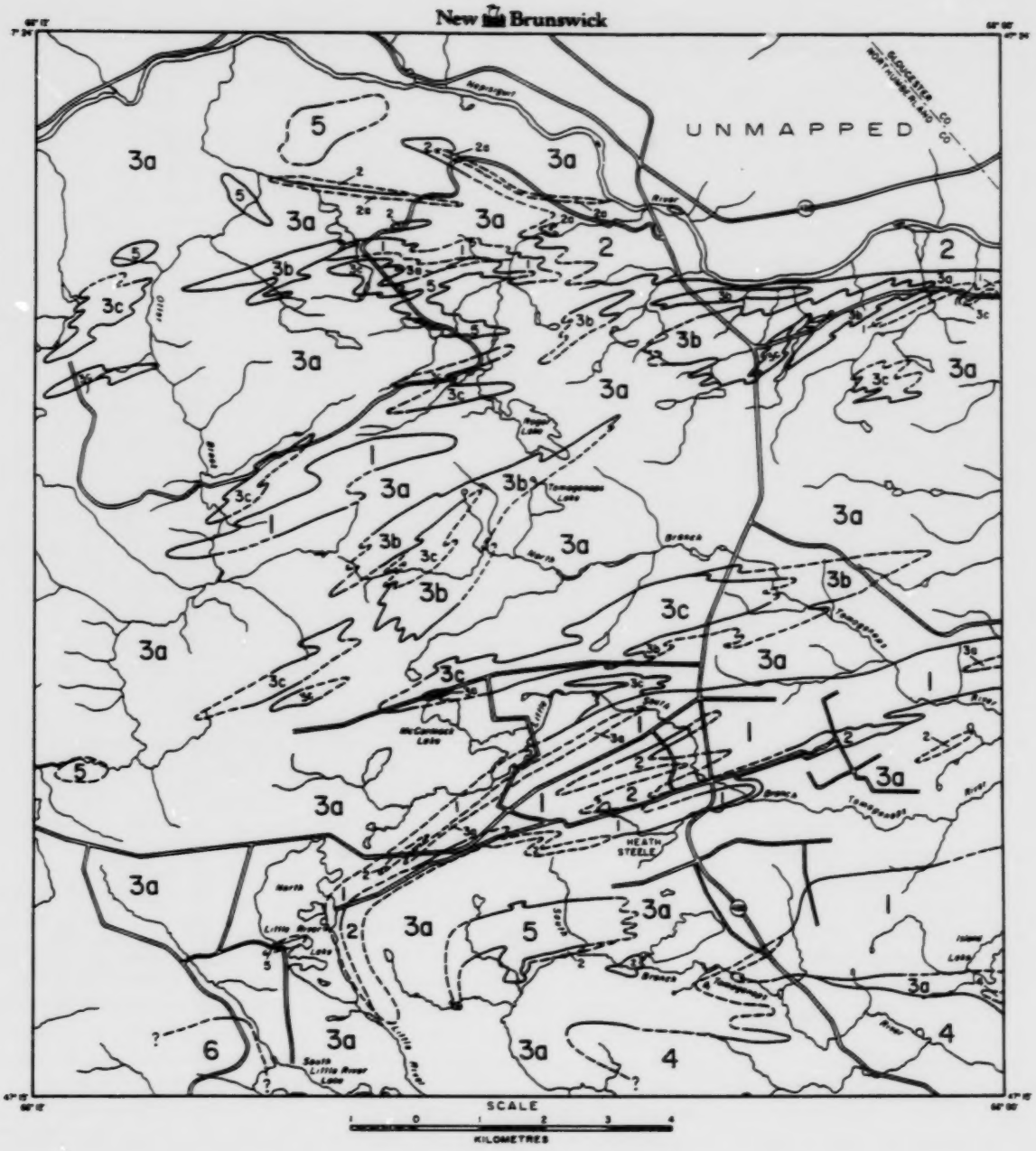


FIGURE 2. Geology of the Heath Steele-Nepisiguit River area. Refer to Figure 1 for location.

A "pseudo-fragmental" facies of these rhyolite lavas is so-called because of the abundance of pale-coloured quartzo-feldspathic nodular spherulites in dark grey altered groundmass, producing a texture that, especially in the more highly strained rocks, resembles that of a welded tuff. However, the monomict nature of these "fragments" and the apparent absence

LEGEND

6 Pink monzonite

5 Light to dark green metagabbro and metadiorite

4 Green, massive to pillowed metabasalt; local minor interbedded red hematitic siltstone

3 Mainly glassy rhyolitic lavas; local minor sedimentary rocks
- 3a: Dark grey or green aphyric rhyolite (metarhyolite, felsic schist and massive aphanitic rhyolite); includes Units 3b and 3c locally
- 3b: Dark grey or green feldspar-phyric metarhyolite and felsic schist
- 3c: "Pseudo-fragmental" facies - mainly tectonized spherulitic rhyolite (devitrified facies of Units 3a, 3b); includes local (apparent) pyroclastic and hyaloclastic rocks (true fragmental rocks).

2 Siltstone, argillite, quartzose and lithic wackes (locally manganiferous and/or graphitic); includes local volcaniclastic sediments
- 2a: red, hematitic chert, slate, or siltstone

1 Grey or pink quartz-feldspar porphyry; minor feldspar-quartz porphyry

——— — — Geological contact; approximate, assumed

of pumice or broken crystals argues against a pyroclastic origin. Where deformation is less intense, they are clearly recognizable as spherulites, indicated by their typically nebulous margins, relatively uniform size and shape, and invariant composition.

The feldspar-phyric and "pseudo-fragmental" units shown in Figure 2 probably outline individual flows or domes, as phenocryst populations and devitrification styles reflect specific pre- and post-eruptive conditions, respectively, which are diagnostic of specific flow units. Local exposures of a breccia consisting of angular monomict felsic fragments in a

granular rhyolitic groundmass may be hyaloclastic breccias resulting from quench-shattering and spalling of the rapidly cooled margins of subaqueous rhyolitic domes or flows. In a few cases, polymict fragmental rocks may be pyroclastic in origin, although thin sections will be needed to confirm this. The paucity of pyroclastic rocks may be related to the subaqueous setting of volcanism, which is consistent with the common relict glassy textures, and association with local beds of marine sedimentary rocks.

The other main type of felsic volcanic rock in the survey area is quartz-feldspar porphyry, which occurs as two varieties: 1) an interpreted intrusive porphyry characterized by relatively large and abundant euhedral crystals, and 2) an apparent effusive porphyry characterized by generally smaller and less abundant crystals, in an aphanitic groundmass. In places, these rocks may be termed quartz-feldspar augen schists, but in general they are not strongly deformed.

Sedimentary rocks comprising a relatively thick unit near the Nepisiguit River include quartzose and lithic wackes (probably volcaniclastic) and argillites, locally manganiferous or graphitic. A thin unit of hematitic slate and chert is closely associated with these rocks. Further south, near Heath Steele, sedimentary rocks include laminated to thin-bedded siltstones (locally strongly deformed), grey to green quartz wacke, chloritic metasedimentary rocks, and local felsic volcaniclastic rocks containing small quartz "eyes" or pebbles.

Massive to pillowed basalts underlie the southeast corner of the map area, and contain minor interbeds of red hematitic siltstone. Mafic intrusive rocks occur as small stocks, and as isolated outcrops, probably dykes, throughout the survey area.

GEOLOGY OF THE POTTERS LAKE MAP AREA, CHARLOTTE COUNTY, NEW BRUNSWICK (PROV)

L.R. Fyffe, Senior Geologist

The Potters Lake map area of southwestern New Brunswick is underlain by Ordovician sedimentary and minor volcanic rocks of the Cookson Group, which have been intruded by several Silurian to Devonian plutons. The Cookson Group is divided into three units: wacke and slate of the Woodland Formation; quartz arenite, slate, and tuff of the Kendall Mountain Formation; and laminated siltstone and slate of the Digdeguash Formation. The foliated Allen Brook and Mohannes plutons were emplaced syntectonically and are probably Silurian in age. The massive St. Stephen and Baring plutons were intruded in the late Silurian or early Devonian, following the main period of folding. The deformation, low-pressure metamorphism, and bimodal plutonism in the St. Croix Terrane is attributed to continental convergence of Avalon and North America.

La région de la carte de Potters Lake au sud-ouest du Nouveau-Brunswick comprend des roches sédimentaires et un peu de roches volcaniques d'âge ordovicien du groupe de Cookson qui ont été pénétrés par plusieurs plutons siluriens et dévoniens. Le groupe de Cookson est divisé en trois unités : des wackes et des ardoises de la formation de Woodland; des arénites de quartz, des ardoises, et des tufs volcaniques de la formation de Kendall Mountain; et des microgrès rubannés et des ardoises de la formation de Digdeguash. Les plutons métamorphisés d'Allen Brook et de Mohannes furent emplacés syntectoniquement et sont probablement d'âge silurien. Les plutons massifs de St. Stephen et de Baring furent pénétrés durant le silurien supérieur ou le dévonien inférieur, après la principale période de plissement. La déformation, qui est attribuée à la convergence continentale d'Avalon et de l'Amérique du Nord, se traduit par un métamorphisme de basse pression et un plutonisme bimodal dans la formation de St. Croix.

INTRODUCTION

Mapping of the Potters Lake map area (1:20 000 scale; part of the St. Stephen 1:50 000 map area) during the summer of 1990 was a continuation of a project begun in 1988 to examine the stratigraphic and structural relationships between various Paleozoic units recognized in southwestern New Brunswick (Fyffe 1989, 1990). Poor exposure, insufficient age control, and complex deformation hampers efforts to document the tectonic history of the region, so that interpretations presented herein should be regarded as somewhat conjectural in nature.

The Potters Lake map area (NTS 21 G/3f) is underlain by rocks of the St. Croix Terrane (Figure 3), a belt of Ordovician sedimentary and minor volcanic rocks intruded by plutonic rocks probably ranging in age from Silurian to Early Devonian. Previous work in the region included mapping by MacKenzie (1940) and MacKenzie and Alcock (1960), and a comprehensive structural study by Ruitenberg (1967) immediately to the northeast of the Potters Lake area.

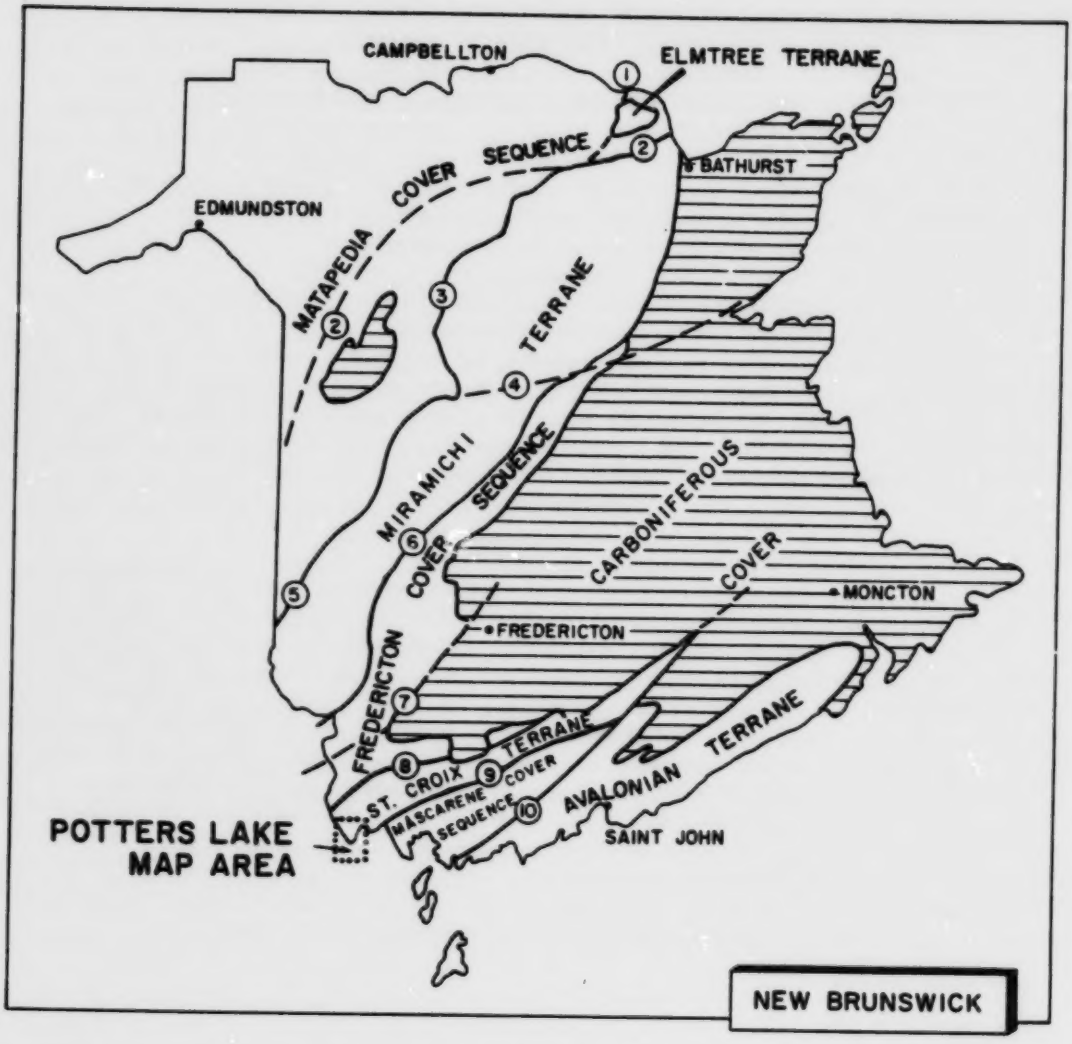


FIGURE 3. Tectonostratigraphic terranes and cover sequences of New Brunswick with location of the Potters Lake map area. The Elmtree and Miramichi terranes are, respectively, Early Ordovician oceanic crust and ensialic volcanic rocks generated in a back-arc setting. The St. Croix Terrane is an Ordovician sedimentary clastic wedge presumably deposited off the margin of the Avalonian Terrane. The Avalonian Terrane comprises Precambrian volcanic and sedimentary rocks. The Matapédia, Fredericton, and Mascarene cover sequences are sedimentary and volcanic rocks that were deposited unconformably on the older terranes between the Late Ordovician and Early Devonian. FAULTS: 1 = Jacquet River Fault; 2 = Rocky Brook-Millstream Fault; 3 = Portage Lakes-Serpentine River Fault; 4 = Catamaran Fault; 5 = Woodstock Fault; 6 = Bamford Brook-Hainesville Fault; 7 = Fredericton Fault; 8 = Basswood Ridge-Pendar Brook Fault; 9 = Falls Brook-Taylor Brook Fault; 10 = Belleisle-Wheaton Brook Fault.

LITHOLOGICAL UNITS

The supracrustal rocks of the Potters Lake area (Figure 4) are assigned to the Cookson Group as defined by Ruitenberg (1967) and revised by Ludman (1987) and Fyffe (1989). The Woodland Formation (Unit Ow) of the Cookson Group is a sequence of rhythmically interstratified, thin- to medium-bedded (2-20 cm) quartzofeldspathic wacke and grey slate that, everywhere within the map area, is spotted with porphyroblasts of cordierite. The Woodland Formation is interpreted to be gradationally overlain by the Caradocian Kendall Mountain Formation (Ludman 1987; Fyffe 1989), but this could not be confirmed in the project area as exposures are lacking in the vicinity of the contact.

Black slate and quartz arenite typical of the Kendall Mountain Formation (Unit Ok) are exposed east of Maxwell Crossing in the northeastern part of the area. Thick quartzose beds, locally containing coarse volcanic-derived detritus (northwest of the Mohannes pluton) and a thin layer of mafic tuff (along Mohannes Stream to the southwest of the pluton) are also included in the Kendall Mountain Formation following the definition of Ludman (1987). Dark and light grey laminated siltstone and slate, assigned to the Digdeguash Formation (Unit Od) as described by Ruitenberg (1967), are assumed to be separated from the Kendall Mountain Formation by a fault running along Soap Brook [the extension of the Honeydale Fault recognized to the northeast by Ruitenberg (1967)].

A highly deformed gabbroic body containing abundant rafts of the surrounding country rock is referred to here as the Allen Brook pluton (Unit Sa). Augen of hornblende that have been rotated into alignment in a fine-grained recrystallized mosaic of plagioclase and quartz define a prominent cataclastic foliation within the gabbro. In the southernmost part of the pluton, the foliation has been overprinted by radiating bundles of actinolite produced by the contact effects of the nearby St. Stephen pluton. Parallelism of the foliation in the gabbro with the gently-dipping crenulation cleavage in the sedimentary rafts indicates that the deformation in the Allen Brook pluton was coeval with the second deformation event recorded in the country rocks (see section on structure). The gabbro is likely older than the relatively undeformed Late Silurian to Late Devonian plutons in the region and is tentatively assigned a Silurian age.

The northeastern part of the Mohannes pluton (Unit Sm) comprises medium-grained, cataclastic granodiorite to monzogranite containing large rafts of fine- to medium-grained gabbro and sedimentary country rocks. The cataclastic fabric is defined by the preferred orientation of plagioclase and alkali feldspar augen set in a fine-grained matrix of recrystallized quartz. Biotite is kinked and largely altered to chlorite. The steeply-dipping, axial planar cleavage of

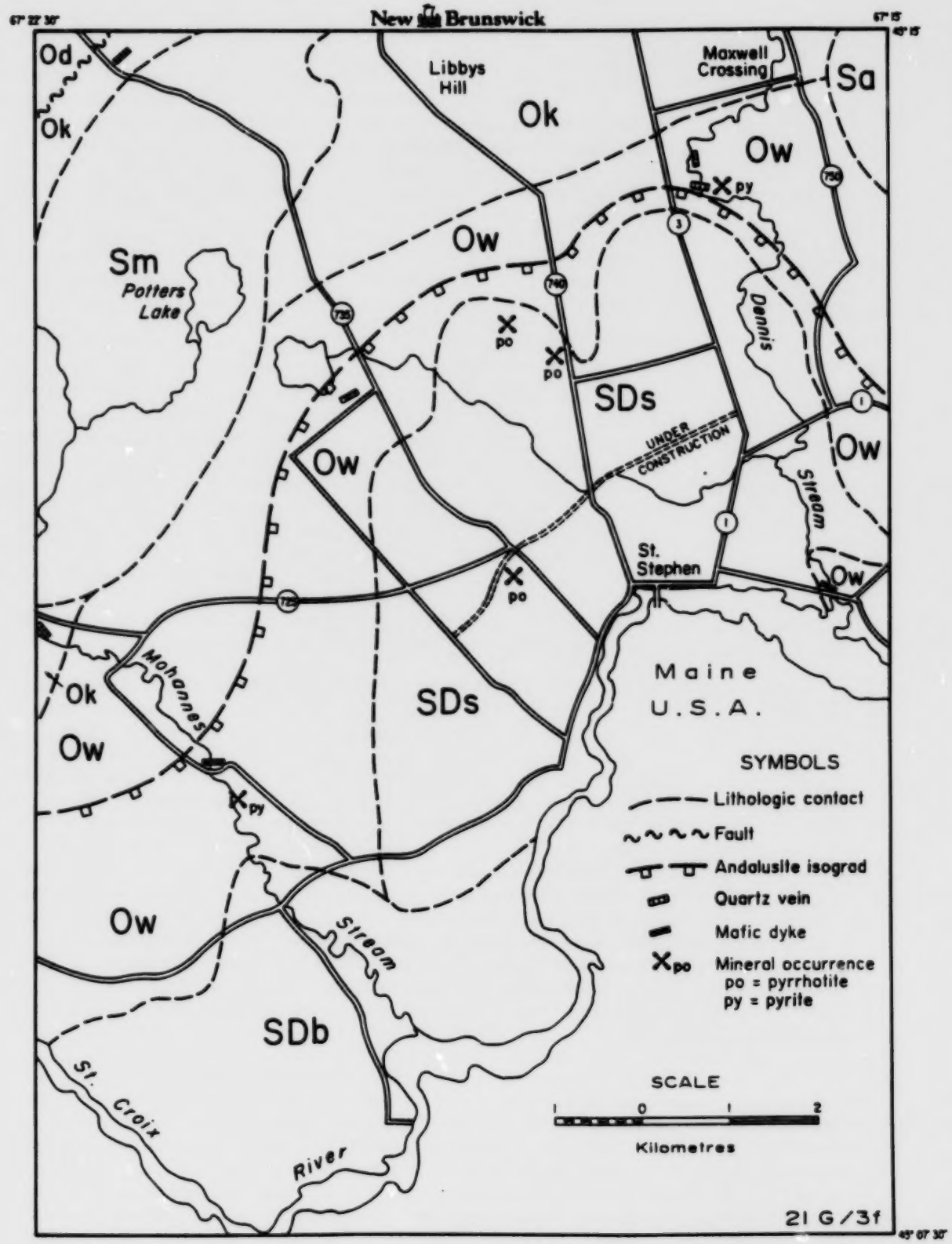


FIGURE 4. Geology of the Potters Lake map area (NTS 21 G/3f).

LEGEND

LATE SILURIAN TO EARLY DEVONIAN

Baring Pluton (SDb): Grey, biotite-hornblende quartz diorite grading to light pink, biotite granite; minor granophyric granite

St. Stephen Pluton (SDs): Peridotite, layered troctolite, anorthosite, norite, and gabbro

SILURIAN

Mohannas Pluton (Sm): Light grey, cataclastic biotite granodiorite and monzogranite containing augen of plagioclase; minor equigranular muscovite granite and foliated gabbro

Allen Brook Pluton (Sa): Dark green, foliated gabbro

ORDOVICIAN

COOKSON GROUP

Kendall Mountain Formation (Ok): Light grey, medium- to thick-bedded quartz arenite interstratified with black pelite; minor granule conglomerate and mafic tuff

Digdeguash Formation (Od): Interstratified dark and light grey slate and siltstone

Woodland Formation (Ow): Thin- to medium-bedded, grey quartzofeldspathic wacke interstratified with dark and light grey laminated slate; minor calc-silicate beds

second phase folds in contained sedimentary rafts is parallel to the cataclastic foliation in the enclosing granite indicating that the Mohannes pluton was emplaced synchronous with, or prior to, the second deformational event and is likely coeval with the Allen Brook pluton. Randomly oriented crystals of andalusite and staurolite in the rafts suggest that metamorphic crystallization within the interior of the Mohannes pluton outlasted deformation.

No outcrops of the Mohannes pluton were found to the southwest of Potters Lake, but large blocks of equigranular muscovite granite are plentiful on the slopes bordering Mohannes Stream. Although this granite is unfoliated, primary muscovite in the granite and muscovite replacing cordierite in sedimentary rocks in the contact aureole are kinked proving that some deformation has affected the southwestern part of the pluton.

The St. Stephen pluton (Unit SDs) has recently been mapped in detail by Paktunc (1989), who divided it into three zones: 1) an ultramafic zone of peridotite and layered troctolite; 2) an olivine-bearing mafic zone of troctolite, olivine norite, olivine gabbro, and minor anorthosite; and 3) a mafic zone of gabbro and minor norite. Examination of the western boundary of the pluton confirmed the more southerly extent of the gabbro as mapped by MacKenzie and Alcock (1960), rather than the restricted limit shown by Paktunc (1989). A Late Silurian or Early Devonian age for the St. Stephen pluton is suggested by its co-mingling relationship with felsic rocks of the Baring pluton (see below).

Paktunc (1989) recognized a poorly developed deformational fabric within the St. Stephen pluton, which he tentatively related to the second period of folding in the area. However, the north-northeasterly trend of this fabric has an orientation similar to the attitude of third folds (see section on structure), consistent with the marked discordance between the pluton and the earlier, penetrative, northeast-trending cleavage in the sedimentary country rocks, and undeformed character of the robust andalusite and cordierite in the contact aureole.

The Baring pluton (Unit SDb) forms one of several large granitic plutons underlying southern New Brunswick and adjacent Maine (Amos 1963). The heterogeneous nature of the intrusion is evident from exposures along the St. Croix River and Mohannes Stream. A zone of fine-grained, granophyric, biotite granite, enclosing blocks of sedimentary rocks and gabbro, occurs within a few tens of metres of the contact with the Cookson Group. Angular blocks are abundant and presumably represent detached roof pendants (Figure 5); granite veins injecting the blocks exhibit flow-aligned plagioclase and biotite schlieren. The few outcrops present further from the contact consist either of medium-grained, light pink, biotite

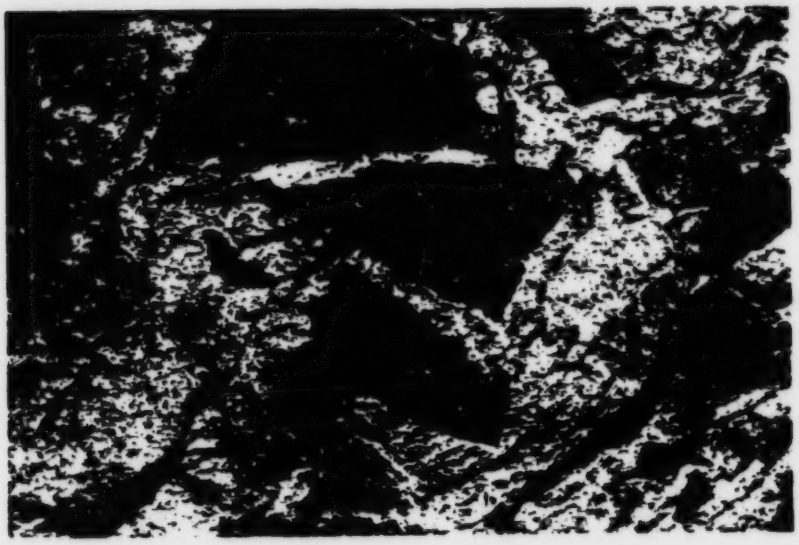


FIGURE 5. Gabbro blocks in Baring granite, St. Croix River.

monzogranite or medium-grained, grey quartz diorite containing poikilitic biotite and hornblende. The quartz diorite was likely produced by assimilation of gabbro by the granite (Amos 1963; Hill and Abbott 1989). A potassium-argon date of 418±19 Ma on hornblende from a granodioritic vein, cutting gabbro of the St. Stephen pluton, suggests Late Silurian or Early Devonian age for the Baring pluton. Similar ages have been obtained from other plutons in Maine and New Brunswick (Hill and Abbott 1989; Bevier and Whalen 1990).

STRUCTURE

The structural complexity of the Cookson Group has previously been described by Ruitenberg (1967) and Stringer and Burke (1985). Outcrops that can be viewed in three dimensions are rare in the region, making it difficult to correlate the various fold generations throughout the map area. Limited data in the Potters Lake area tend to support the deformational history proposed by Ruitenberg (1967) in the Rollingdam area to the northeast. However, the domal structure of the Cookson Group cannot be an early feature as envisioned by Ruitenberg (1967), as recent fossil evidence indicates that the core of the so-called dome is underlain by the youngest strata (Fyffe 1990).

The variation in attitude of bedding in the Potters Lake area (Figure 6) can be attributed to at least three, approximately co-axial generations of folding. The first (F_1) and second (F_2) folds are generally tight and are associated with penetrative, axial planar cleavages, whereas the third folds (F_3) are open folds or kinks without an

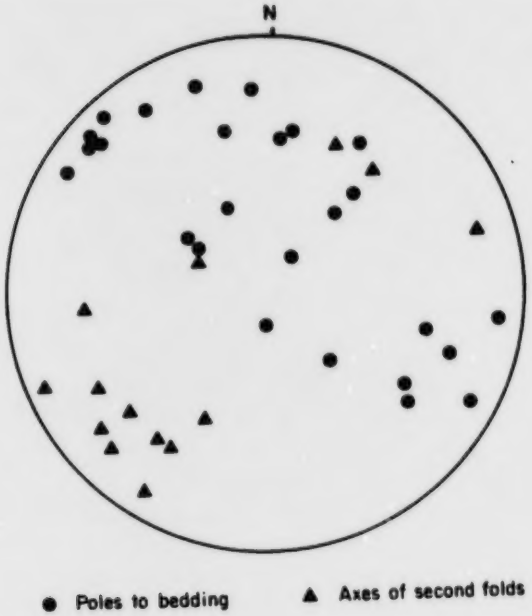


FIGURE 6. Stereogram with poles to bedding and axes of second folds.

associated penetrative cleavage. The most common fold closures observed in the area (Figure 6) are considered to belong to the second generation, as both bedding and a cleavage appear to be folded.

Interference patterns between first and second folds have been seen only in three localities. At Libbys Hill (Figure 3), tight, shallow-plunging folds (F_1) with a steep, northeast-trending axial planar cleavage are refolded by more open folds (F_2) with an axial planar, crenulation cleavage dipping gently to the northwest (Figures 7, 8). Along the St. Croix River (to the west of the Potters Lake area) and along Dennis Stream, recumbent, isoclinal folds (F_1) are refolded by open to tight folds (F_2) with steep axial planar cleavage (Figure 9). This corresponding change in attitude of the earlier tight fold set (F_1) from steep to shallow with the change from shallow to steep for the later, more open folds (F_2) is consistent with their refolding by a third set (F_3) of northeast-trending, open folds (Figure 10).

Multiple episodes of high-grade metamorphism in the Potters Lake area appear to coincide with the emplacement of various intrusions during distinct stages of structural development. For example, staurolite porphyroblasts north of the Allen Brook pluton contain straight inclusion trails of muscovite, which have grown parallel to the axial plane of F_1, whereas crenulations associated with F_2 are flattened around the

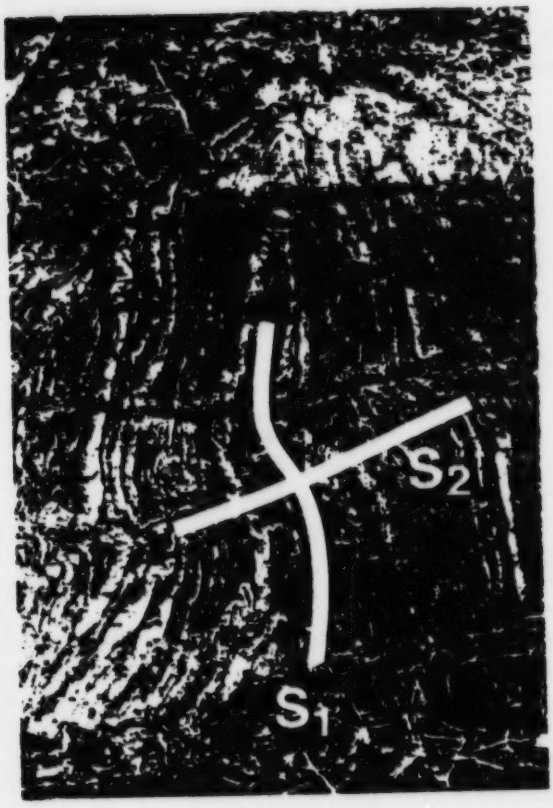


FIGURE 7. Interference pattern between first (F_1) and second (F_2) folds at Libbys Hill. S_1 and S_2 denotes their respective steep- and gentle-dipping axial surfaces.

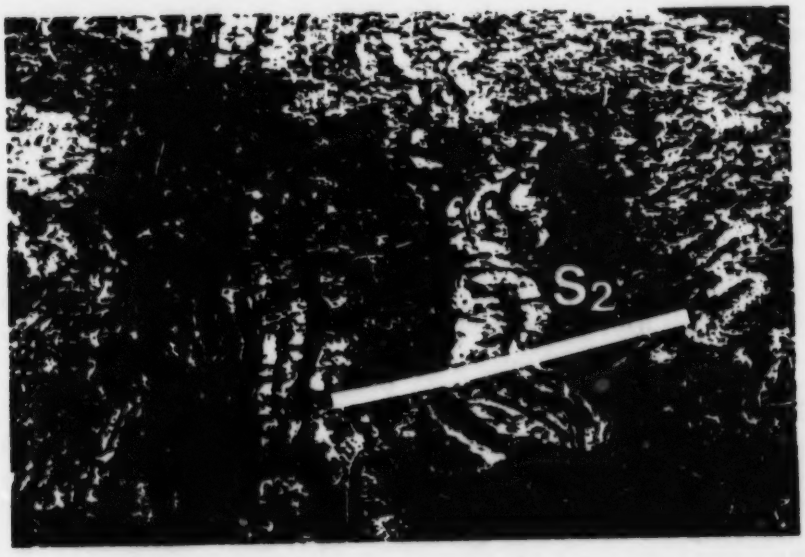


FIGURE 8. Second folds (F_2) with gently dipping axial planar crenulation cleavage (S_2) at Libbys Hill.

porphyroblasts. Thus, the growth of these staurolites (post-F_1 but pre- to syn-F_2) in relation to deformation corresponds closely to the time of intrusion of the Allen Brook gabbro. Cordierite porphyroblasts to the west of Libbys Hill and on Dennis Stream overprint and contain pressure shadows within the crenulation cleavage suggesting growth during F_2-deformation. These cordierites are likely related to emplacement of the Mohannes and Allen Brook plutons, respectively. As previously noted, the presence of undeformed andalusite and cordierite porphyroblasts along the margins of the St. Stephen and Baring plutons indicates that these intrusions were emplaced after penetrative F_2-deformation.

TECTONIC SYNTHESIS

The compressive structural features within the Cookson Group of the St. Croix Terrane are considered to have resulted from continental collision between the Avalon Terrane and North America (Fyffe and Fricker 1987). This collisional event must have begun after deposition of the continental rise deposits of the Cookson Group, i.e., after the Caradocian (mid-Ordovician). Debris-flow deposition along the St. Croix-Avalon boundary, recorded in the Late Silurian Oak Bay Formation (Gates 1989), presumably reflects tectonic uplift at high crustal levels during continental convergence. Low-pressure metamorphism and generation of syn- to post-tectonic, bimodal magmatism in the St. Croix Terrane suggests a relatively slow rate of lithospheric thickening involving both crust and upper mantle (Patino-Douce et al. 1990; Loosveld and Etheridge 1990). Such a model is consistent with the Silurian to Late Devonian age range (greater than 50 Ma) for plutonism in southern New Brunswick and adjacent Maine.

ECONOMIC GEOLOGY

The St. Stephen pluton hosts several zones of Ni-Cu sulphide mineralization, the largest being the Rogers Farm and Hall-Carroll prospects near the northern margin of the intrusion (Dunham 1950). The mineralization apparently formed by magmatic segregation followed by a period of brittle deformation during which the sulphides further concentrated, remobilized, and emplaced as massive lenses into northeast-trending fracture zones (Paktunc 1989).

During the mapping project, a massive pyrrhotite lens approximately 1 m thick was discovered in the central part of the St. Stephen pluton, along the newly constructed by-pass to the north of St. Stephen (Figure 4). This new occurrence implies that controls other than proximity to the country-rock contact influence the localization of sulphide mineralization and need to be taken into consideration during selection of exploration targets.

Numerous gold showings, generally localized in quartz veins

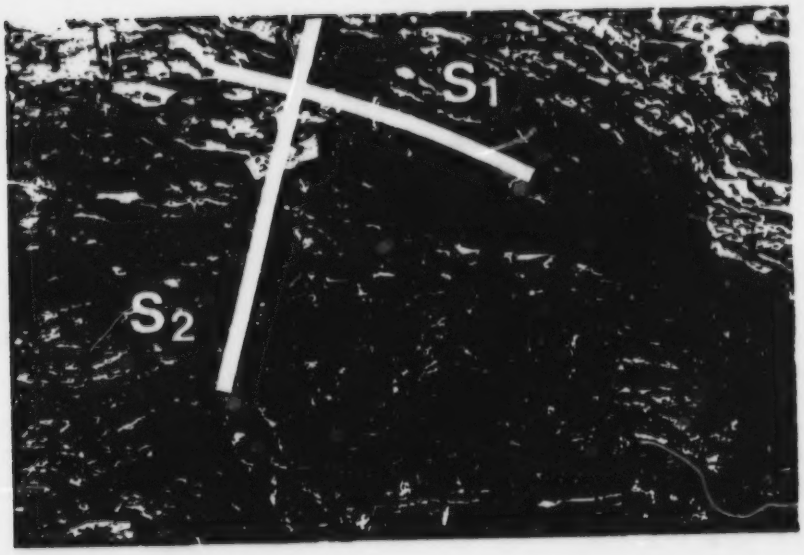


FIGURE 9. Interference pattern between first (F_1) and second (F_2) folds below Woodland dam on the St. Croix River. S_1 and S_2 denote their respective gentle- and steep-dipping axial surfaces.

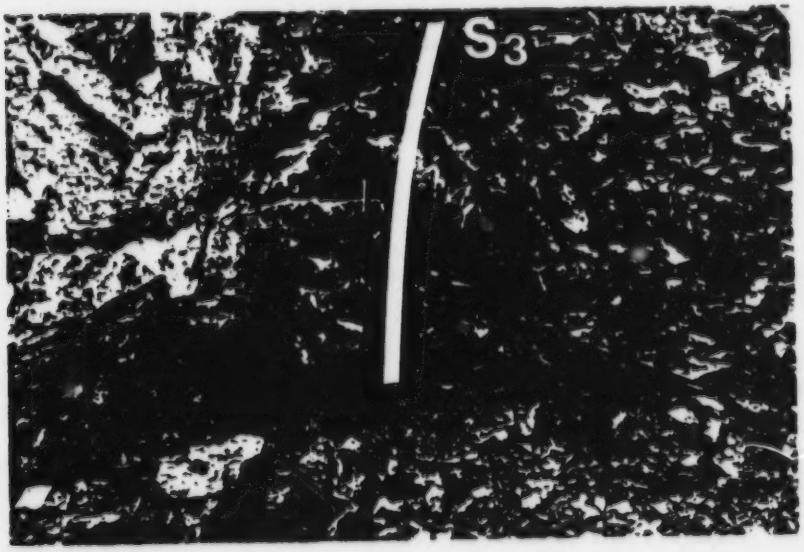


FIGURE 10. Open third fold (F_3) in rock quarry near Woodland dam.

along northeast-trending fractures, have been reported from the St. Croix Terrane. In the Rollingdam area, anomalous gold values are associated with arsenopyrite in quartz veins apparently related to emplacement of a large felsic pluton (Ruitenberg 1967). Major quartz veins along prominent fault zones have been the focus in the search for gold in the Scotch Ridge area (Fyffe 1989). In the Potters Lake map area, pyrite-bearing quartz veins were noted along Dennis Stream, where they are found parallel both to the axial planar cleavage of northeast-trending second folds and to the north-trending kink bands of third generation folds.

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STRUCTURAL TRENDS BENEATH THE CARBONIFEROUS COVER OF SOUTHERN NEW BRUNSWICK (PROV)

L.R. Fyffe

Distinctive Precambrian (Avalonian), Ordovician (St. Croix), and Silurian (Fredericton) belts exposed in southern New Brunswick are extended northeastward beneath covering Carboniferous strata using borehole and magnetic data. Faults bounding these belts are correlated with structures recognized in Prince Edward Island on the basis of recently published offshore seismic interpretations.

Des zones distinctives d'âges précambrien (avalonien), ordovicien (St. Croix) et silurien (Fredericton) affleurent dans la partie sud du Nouveau-Brunswick. Les données magnétiques et de forage permettent de prolonger ces zones vers le nord-est sous les couches carbonifères. De plus, à partir de l'interprétation récente de levés sismiques marins, les failles qui limitent ces zones ont été mises en relation avec des structures de l'Île-du-Prince-Édouard.

The continuation of distinct, fault-bounded, stratigraphic belts underlying southern New Brunswick (Fyffe and Fricker 1987, Figure 11) can be traced to the northeast beneath covering rocks of Carboniferous age using borehole, magnetic, and seismic data. (1) The southernmost belt comprises Precambrian limestone (Green Head Group) and volcanic rocks (Coldbrook Group) locally overlain by platformal Cambrian to Early Ordovician sedimentary rocks (Saint John Group). This belt has been correlated with the Avalonian rocks of Newfoundland (Rast et al. 1976). (2) A belt of Silurian to Early Devonian volcanic rocks (Mascarene Group) separates the Avalonian belt from Ordovician rocks of the St. Croix belt to the north. These volcanic rocks lense out to the northeast between converging faults zones and do not extend beneath the Carboniferous cover (McLeod et al., this volume). (3) The Ordovician St. Croix belt is considered to include clastic turbidites of the Cookson Group (Ruitenberg 1967; Ludman 1987; Fyffe 1990) in the southwest and unnamed volcanic rocks, wackes, and black slates in the Annidale area to the northeast (McLeod et al. 1990). (4) Calcareous sandstone and slate (Flume Ridge Formation) of the Fredericton belt separates the St. Croix belt of southern New Brunswick from Cambrian to Ordovician sedimentary rocks of the Miramichi belt in central and northern New Brunswick.

Precambrian volcanic and granitic rocks of the Avalonian belt are exposed in inliers surrounded by Carboniferous rocks at Jordon Mountain (F on Figure 11) and Indian Mountain (G on Figure 11), and were intersected in the Westmorland and Port Elgin boreholes southeast of Moncton (Figure 11). Magnetic trends (see Geological Survey of Canada Map NK/NL20) indicate that these rocks continue northeastward to the Egmont Bay area

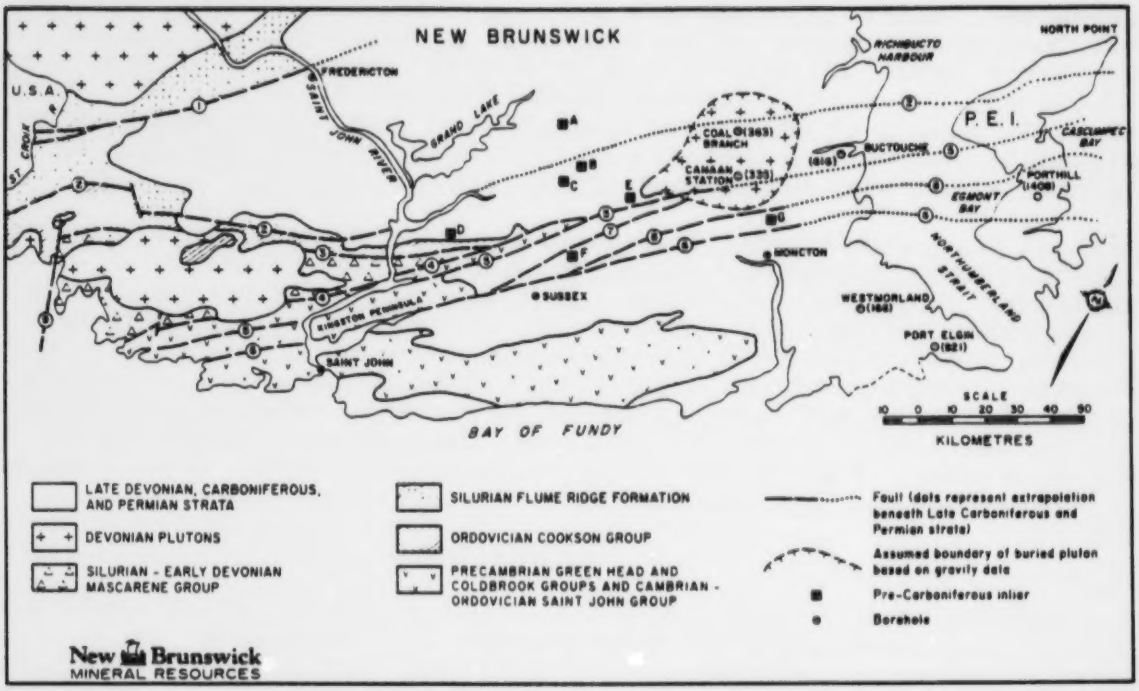

FIGURE 11. Geology map of southern New Brunswick and northern Prince Edward Island.

FAULTS: 1) Fredericton; 2) Basswood Ridge-Pendar Brook; 3) Falls Brook-Taylor Brook; 4) Wheaton Brook-St. George; 5) Belleisle; 6) Kennebecasis-Berry Mills; 7) Jordan Mountain; 8) Smith Creek; 9) Oak Bay

INLIERS: A) Coal Creek; B) Forks Stream; C) Canaan River; D) Henderson Brook; E) Thornes Brook; F) Jordan Mountain; G) Indian Mountain

Boreholes are denoted by their geographic location. Number in brackets gives depth to basement in metres.

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of Prince Edward Island (Webb 1969; van de Poll 1983). The magnetic data also suggest that the northern limit of the Precambrian belt coincides with the Belleisle Fault as extended northeastward from its last known location along the southern margin of an inlier at Thornes Brook (E on Figure 11). The extension of other faults within the Avalonian belt into Prince Edward Island has been discussed in some detail by St. Peter and Fyffe (in press).

Preserved Ordovician volcanic rocks and slates similar to those belonging to the St. Croix belt are exposed in the Thornes Brook inlier (E on Figure 11). Boreholes at Canaan Station and Coal Branch reveal that this belt is truncated to the east by a large granitic pluton mostly buried beneath the Carboniferous cover, but partly exposed in the Thornes Brook inlier. However, a borehole at Buctouche intersected graphitic slate (McMullan 1920) suggesting that the St. Croix belt does continue at least as far east as Northumberland Strait.

The easternmost expcsures of Silurian sedimentary rocks of the Flume Ridge Formation are found in an inlier at Coal Creek (A on Figure 11). These Silurian rocks are assumed to extend offshore under the North Point Basin and to be separated from the Ordovician rocks to the south by a fault identified through the northwestern tip of Prince Edward Island by Durling and Marillier (1990) on the basis of seismic data. This fault can be correlated with the Basswood Ridge-Pendar Brook Fault, which separates the Flume Ridge Formation from the Digdeguash Formation in northwestern New Brunswick (Fyffe 1990).

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GEOCHEMISTRY

Toon Pronk, Geochemist

Sampling over the Pokiok Batholith started last year with the Canterbury map area (21 G/14) and was continued this year in the McAdam, Forest City, and Fosterville map areas (21 G/11, 12, and 13). Sampling procedures, quality control, and analytical methods will meet the GSC's National Geochemical Reconnaissance standards. This survey area is also the subject of a surficial mapping/till sampling program carried out under auspices of Allen Seaman. The mineral potential of the area, along with certain environmental and forestry management concerns, and the fact that part of the area is in the St. Croix international watershed, makes it a prime area to promote the role of geology in land-use planning.

The position left vacant in the lab a year and a half ago upon retirement of our lab assistant was filled in May by Rex Boldon, who transferred from Region 5. Rex brings field experience to the job and has spent most of his first summer with us sampling stream sediment and water, assisted by two summer employees.

The Report of Investigation on the MDA I till geochemistry/ surficial mapping project areas is presently awaiting some modifications to the bedrock geology base that will accompany the report. Till geochemistry of the Nepisiguit Lakes area (21 O/7) is also awaiting finalization of accompanying maps, which are in the last stages of completion.

Till geochemistry of the Alma/Hillsborough areas (21 H/10, 15) was released this summer, while sampling took place two summers ago (Foisy 1990). The Waterford map area (21 H/11) was mapped in 1989. Results will be released at a later date.

With the termination of MDA I we "inherited" the till samples from the Miramichi Zone project (Lamothe, GSC). The samples are being archived and splits of the original samples will be used for mineralogy studies in selected areas. Heavy minerals are being concentrated with the use of gold wheels, a shaker table, and heavy liquid separation. Ed Hornibrook is presently working on samples from the Trout Brook area (21 J/10) as part of his BSc program, under supervision of Professor John Spray, and with guidance from Bill Gardiner and Toon Pronk. He is looking at the mineralogy and glacial dispersal of known mineral occurrences in the area.

Analyses of drill-core samples from the Carboniferous drilling project are near completion and an updated file will be published as soon as old and new databases are joined to create one easily accessible format. Recent work on groundwater geochemistry (Dan Boyle, GSC) in the Carboniferous Basin

has pointed out a new use for these data. More "background" data will be generated from rock samples collected during provincial mapping projects. These rocks are archived and listed similar to the drill core kept in our storage facility by Greg Crouse.

Toon Pronk gathered information for mining week on applied geology, and how geology affects people's everyday lives. A few of the subjects were; minerals, peat, building materials, drinking water, hydrothermal energy, forestry resources, and acid-rain sensitivity. Barbara Carroll, Gerry Johnson, and Terry Leonard put all the information together in an eye-catching display. The display was subsequently used for science awareness programs throughout the Province, and can be borrowed from our Geoscience Data Section.

From June 3-6, Toon Pronk attended the first joint meeting of the American and Canadian Quaternary associations (AMQUA and CANQUA), which was held in Waterloo, the theme being "Rapid change during the Quaternary", with the focus on global change. Many of the presentations dealt with the registration of atmospheric trace gas quantities in the "recent" geological records, how these have affected our climate zones and weather patterns, and how they may affect us in the (near) future. Toon Pronk presented a paper on the glacial history of the northern Miramichi Highlands at this meeting.

Toon Pronk represented the Geological Surveys Branch of the Mineral Resources Division in the Green Plan Workshop held in Fredericton in June 1990. In general, the meetings underlined the need (1) to improve the public image of the mineral industry, and (2) for the industry to be well represented in setting guidelines for sustainable development.

Toon Pronk gave a paper on the status of geochemistry surveys, archiving of samples, and data storage and retrieval in New Brunswick as part of the geochemical workshop organized by Bill Gardiner for prospectors and industry, which was held in late September.

GÉOCHIMIE

Toon Pronk, géochimiste

L'échantillonnage du batholite Pokiok a débuté l'année dernière avec la région de la carte de Canterbury et s'est poursuivi cette année dans les régions des cartes de McAdam, de Forest City et de Fosterville (21 G/11,12 et 13). Les procédés d'échantillonnage, le contrôle de la qualité et les standards analytiques rencontreront les normes du programme de reconnaissance géochimique nationale de la Commission géologique du

Canada. Cette zone de levé fait aussi l'objet d'un programme de cartographie des dépôts meubles et d'échantillonnage du till exécuté sous les auspices d'Allen Seaman. Le potentiel minier de la région, de même que certaines inquiétudes liées à l'environnement et à la gestion des forêts, et le fait qu'une partie de la zone se trouve dans le bassin versant international de Ste-Croix, en font un endroit privilégié pour promouvoir le rôle de la géologie en planification de l'utilisation des terres.

Le poste demeuré vacant dans nos laboratoires il y a un an et demi, lors du départ de notre assistant de laboratoire, a été comblé en mai par Rex Boldon, transféré de la région 5. Rex possède une bonne expériences de terrain et il a passé la majeure partie de son premier été avec nous à échantillonner l'eau et les sédiments de ruisseau, avec l'aide de deux employés d'été.

Le rapport d'investigation des zones du projet de géochimie des tills et de cartographie des dépôts meubles du MDA I est présentement en attente de modifications quant au résumé de la géologie du socle qui accompagnera ce rapport. La géochimie des tills de la région des lacs de Nepisiguit (21 O/7) est aussi en attente de finalisation des cartes de support, lesquelles se trouvent à la dernire étape d'achèvement.

La géochimie des tills de la région d'Alma/Hillsborough (21 H/10, 15) est disponible depuis cet été, alors que l'échantillonnage avait eu lieu en été 1988 (Foisy 1990). La région de la carte de Waterford (21 H/11) a été cartographiée en 1989 et les résultats seront publiés à une date ultérieure.

Avec la fin du MDA I nous avons "hérité" des échantillons de till du projet de la zone de Miramichi (Lamothe, CGC). Les échantillons sont maintenant classés en archives et des portions des échantillons originaux seront utilisés pour des études minéralogiques en certains endroits choisis. Les minéraux lourds sont concentrés à l'aide de tables vibrantes et de concentrateurs rotatifs pour l'or, ainsi que par séparation par liquides denses. Ed Hornibrook travaille présentement sur les échantillons de la région de Trout Brook (21 J/10) comme élément de son programme de baccalauréat, sous la supervision du professeur John Spray, et avec l'aide de Bill Gardiner et Toon Pronk. Il examine la minéralogie et la dispersion glaciaire des gîtes minéraux connus de la région.

Les analyses des carottes du projet de forage du carbonifère sont presque complétées et un dossier revisé sera publié aussitôt que les anciennes et les nouvelles banques de données seront combinées pour créer un fichier unique facilement accessible. Les récents travaux sur la géochimie des eaux souterrainnes (Dan Boyle, CGC) dans le bassin carbonnifère ont démontré une utilisation supplémentaire pour ces données. Des données de base additionnelles seront

produites à partir des échantillons de roche recueillis durant les projets provinciaux de cartographie. Ces roches ont été classées en archives et une liste en a été dressée, comme pour les carottes de forage conservées dans notre entrepôt par Greg Crouse.

Toon Pronk a rassemblé l'information devant servir à la semaine des mines dont le thème portait sur la géologie appliquée, et comment la géologie affecte le quotidien des gens. Quelques-uns des sujets furent : les minéraux, la tourbe, les matériaux de construction, l'eau potable, l'énergie hydrothermale, les ressources forestières et la sensibilité aux pluies acides. Barbara Carroll, Gerry Johnson et Terry Leonard ont produit un montage accrocheur à partir de toute cette information. Le kiosque fut subséquemment utilisé lors de programmes de sensibilisation scientifique à travers la province et peut être emprunté à notre section des données géoscientifiques.

Du 3 au 6 juin 1990, Toon Pronk a assisté à la première rencontre conjointe des associations américaines et canadiennes du quaternaire (AMQUA et ACANQUA), tenue à Waterloo et dont le thème était "Changement rapide durant le quaternaire", avec une emphase sur le changement global. Plusieurs des présentations portèrent sur l'analyse des gaz interstitiels d'origine atmosphérique dans les archives géologiques "récentes", comment ceux-ci ont affecté nos zones climatiques et les patrons météorologiques, et comment ils peuvent nous affecter dans un (proche) avenir. Toon Pronk présenta un article sur l'histoire glaciaire des hautes terres de Miramichi.

Lors de l'atelier du Plan Vert tenu à Fredericton en juin 1990, Toon Pronk a représenté la section des levés géologiques de la division des Ressources minérales. D'une façon générale, les rencontres ont souligné le besoin (1) d'améliorer l'image publique de l'industrie minière, et (2) pour l'industrie d'être bien représentée lors de l'établissement des orientations face à la nécessité d'un développement durable.

Dans le cadre de l'atelier sur la géochimie organisé à la fin septembre par Bill Gardiner pour les prospecteurs et l'industrie. Toon Pronk a présenté un article portant sur l'état d'avancement des levés géochimiques, la classification des échantillons, et l'entreposage et la récupération des données au Nouveau-Brunswick.

QUATERNARY GEOLOGY AND TILL GEOCHEMISTRY OF THE FOREST CITY MAP AREA (NTS 21 G/12), YORK COUNTY, NEW BRUNSWICK (PROV)

A.A. Seaman, Quaternary Geologist

The Quaternary geology of the Forest City map area (NTS 21 G/12, Canadian portion) was mapped during 1990 at a scale of 1:50 000. Samples of till and the overlying soil were obtained from 84 grid blocks comprising 4 km^2 each. Several grid blocks were sampled twice, to permit comparison between different till units. Soil profile descriptions and vegetation summaries were prepared at each sample site. The samples collected will be analysed for the standard multi-element suite used in previous projects of this type.

Most of the area is covered by basal till, often with a surficial ablation lag. However, rolling to hummocky ablation till moraines comprise about 20% of the area. A few small esker segments are present, while lacustrine sediments are found around the margins of the major lakes.

Streamlined, grooved and striated bedrock surfaces, and a till fabric, suggest that initial ice flow was southeastward, followed by southerly to southwesterly flow, and then by eastward flow. However, the data are insufficient for this chronology to be established as fact.

La géologie du quaternaire de la région de la carte de Forest City (SNRC 21 G/12, portion canadienne) a été cartographiée au cours de 1990 à une échelle de 1:50 000. Des échantillons de till et du sol sus-jacent furent obtenus à partir de 84 blocs de levés de 4 km carrés chacun. Plusieurs blocs de levés furent échantillonnés à deux reprises afin de permettre une comparaison entre les différentes unités de till. Pour chacun des sites d'échantillonnage, une description du profil pédologique et un inventaire de la végétation ont été préparés. Les échantillons recueillis seront analysés en fonction de la série multi-élément standard utilisée lors des projets précédents de ce type.

La majeure partie de la région est couverte d'un till de fond souvent accompagné d'un dépôt résiduel de surface. Cependant, des moraines d'ablation variant de ondulée à raboteuse couvrent environ 20 % de la région. Quelques petits segments d'esker sont présents, alors que des sédiments lacustres se retrouvent aux abords des principaux lacs.

La surface du socle montre des écoulements laminaires, des cannelures glaciaires et des stries, ainsi qu'une texture de till, suggérant que l'écoulement glaciaire initial était de direction sud-est, suivi par des écoulements vers le sud et le sud-ouest, et ensuite par des écoulements vers l'est. Cependant, les données sont insuffisantes pour établir cette chronologie avec certitude.

During the summer of 1990, Quaternary geology mapping and till sampling was conducted in the New Brunswick portion of the Forest City (NTS 21 G/12) 1:50 000-scale map area. This area lies within the St. Croix River drainage basin, adjacent to the Chiputneticook Lakes system (to the north of Spednic Lake and east of Grand Lake) (Figure 12). The area lies completely within the area of the Skiff Lake Granite unit (Lutes 1987) of the

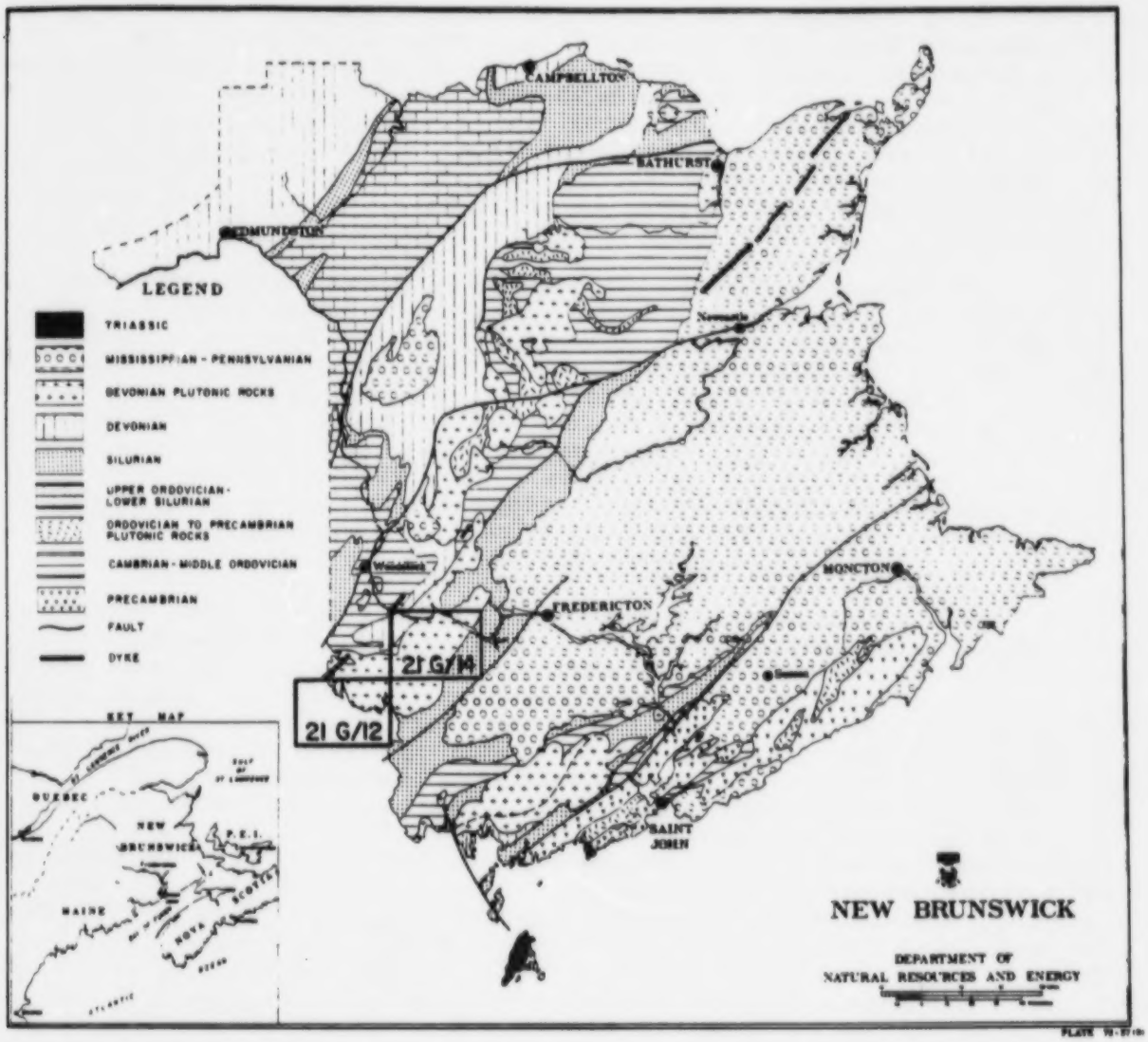

FIGURE 12. Index map for Forest City and Canterbury map areas (NTS 21 G/12, 21 G/14).

Pokiok Batholith. The topography in the area is bedrock controlled, but with a strong glacial overprint, comprising streamlined hills and ridges with interspersed lakes and swampy valleys, all with a southeasterly trend. Local relief is up to 110 m.

The reasons for this study were threefold: 1) to determine the direction of till transport in this part of southwestern New Brunswick for comparison with the apparent northerly transport in the Peltoma Lake area, east of Oromocto Lake (Seaman, in press); 2) to add to the till geochemistry database for New Brunswick; and 3) to collect basic Quaternary geology data on the St. Croix Watershed area.

Till sampling (B- and C- horizons) was carried out at the standard 2 km grid spacing (i.e., one sample per 4 km^2), from a total of 84 grid blocks. Eleven of the blocks were sampled twice, to allow comparison between different till units (usually ablation till units and adjacent basal till units). In addition, four samples were obtained from a 3 m thick till sequence exposed in a borrow pit, to determine the potential for vertical variations in the till composition and geochemistry.

The basal tills in the Forest City area are moderately to extremely dense, gravelly sandy silts to gravelly silty sands, with the siltier tills being predominant. They vary in colour from greyish brown through olive-brown (dominant) and brown to yellowish brown. Surprisingly, for an area lying in the centre of a granite batholith, the content of granitic clasts in these tills is low, with more than half of the samples containing less than 20% granite clasts, and 10% containing none. In contrast, the ablation tills are clean to silty gravelly sands or sandy gravels, of similar colour, but tending to have a much higher granite content - up to 100%.

The tills have also proven to be thicker than expected. Gadd (1973) mapped much of the area around Musquash, Bolton, and East Brook lakes as bedrock, while Rampton et al. (1984) mapped it as morainal veneer, generally less than 0.5 m thick. However, for the 20 basal till sections dug in this part of the area, depths ranged from 0.57 to 1.96 m, with a mean of 0.82 m, and in no instance was bedrock encountered at the base of the section. In comparison, the basal till sections from the remainder of the area varied from 0.49 to 1.51 m in depth, with a mean of 0.80 m, and with two sites bottoming on bedrock (at depths of 0.62 and 0.78 m). Given the paucity of bedrock outcrops throughout much of the map area, it seems likely that average till thickness is generally greater than 1 m.

The most visually obvious characteristic of the area is the large number of granitic blocks and boulders that occur at the surface. Boulder coverage varies from a few per cent of the surface area to virtually 100%, with the ablation tills in particular being extremely bouldery. The abundance of these boulders in the ablation tills, the general lack of them within the basal tills, and their presence in abundance on the surfaces of some basal tills that contain no granitic clasts, all tend to suggest that they were deposited as a surface lag during final melting of the glacier. The presence of granitic boulders on the surfaces of non-granitic tills suggests that the glacier that deposited them flowed from a different direction than did the one responsible for deposition of the basal tills, though this flow direction remains to be identified.

Most of the glacial striae in the area trend toward the southeast, parallel to the glacially streamlined topography. However, apparently younger striae with southerly to south-

westerly orientations have also been observed. A till-fabric measurement in the centre of the borrow-pit section (at the north end of Hinkley Point) suggests that this till was deposited by east- to east-southeast-flowing ice. While scanty, the data appear to be consistent with the chronological model presented last year (Seaman 1989); i.e., strong early southeastward ice flow moulding and streamlining the bedrock surface, followed by later southerly, southwesterly, and then easterly trending flows.

Deposits other than tills are minimal in the area. A few small esker segments are present, and minor occurrences of lacustrine sediments have been encountered along the margins of the major lakes. All of the glacial features are assumed to be of Late Wisconsinan age.

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QUATERNARY GEOLOGY OF THE CANTERBURY MAP AREA (NTS 21 G/14), YORK COUNTY, NEW BRUNSWICK: PRELIMINARY REPORT (MDA)

S.A. Balzer, graduate student, UNB

Field studies conducted during the summer of 1990 indicate that the Canterbury map area (NTS 21 G/14) is the site of a large ablation complex. The presence of thin, irregular, bouldery tills and abundant glaciofluvial sediments supports this concept. At least two basal till units, and possibly a third, have been identified. Glacial flow indicators are well preserved in parts of the map area, revealing predominantly southeast and south-southeast flows. The southeast-trending flow event appears to be the oldest.

Des études de terrain effectuées au cours de l'été 1990 indique que la région de la carte de Canterbury (SNRC 21 G/14) est le lieu d'un grand complexe d'ablation. La présence de tills minces, irréguliers et à blocs erratiques de même que d'abondants sédiments glaciofluviaux supportent ce concept. Au moins deux unités de till de fond, et possiblement une troisième, ont été identifiées. Dans certaines parties de la région, des indicateurs d'écoulements glaciaires sont bien préservés, révélant une prédominance des écoulements vers le sud-est et le sud-sud-est. L'écoulement d'orientation sud-est semble être le plus ancien.

Quaternary geology mapping and till sampling in the eastern half of the Canterbury map area (NTS 21 G/14) (Figure 12) this summer has revealed that most of the area is overlain by ablation and basal tills and esker/outwash systems. The amount of exposed bedrock suggests that the basal till cover is generally thin (<1.5 m) and variable. Surface boulders, predominantly Pokiok Batholith granites, overlie both types of till, and cannot be used to accurately define either. Eskers in the area trend southeastward, and are flanked by extensive outwash plains. A high water table results in the occurrence of extensive boggy areas, which limit access to some parts of the area.

Till mapping, plus sampling at 140 sites on a 2 km grid, has revealed the presence of at least two lithologically distinct basal tills. A sandy granitic till, olive-brown to orange-brown in colour, is common near bedrock highs and esker systems overlying the Pokiok Batholith. These tills contain a high percentage of granite clasts.

The second basal till unit is silty with varying amounts of clay and fine sand. This unit usually overlies Silurian and Carboniferous greywackes, sandstones, and conglomerates. Its colour is mottled with varying degrees of brown, tan, grey, and green. The clast lithology consists of varying proportions of granite and greywacke.

A patchy, grey-pink silty unit of variable lateral and vertical extent occurs locally in the area. Clasts within this unit are well faceted and striated, and of distal origin. This unit is very granitic, and occurs in wet areas with an extensive coverage of granite boulders. It may be a till or a product of surface weathering.

Based on rattails, striae, roche moutonnées, and boulder dispersal patterns, the dominant ice-flow directions are toward the southeast and the south-southeast. These patterns are similar to those noted elsewhere in southwestern New Brunswick. The south-southeast trend apparently cross-cuts features relating to the southeast-directed ice movement. Both trends locally parallel the Saint John River valley.

GEOLOGICAL SURVEYS BRANCH

MINERAL DEPOSITS AND GIS SECTION

ACTIVITIES OF THE MINERAL DEPOSITS AND GIS SECTION

R.R. Irrinki, Senior Geologist

The Mineral Deposits and GIS section staff consists of Rao Irrinki (Senior Geologist), Bill Gardiner (Mineral Deposits Geologist), Greg Crouse (Core Manager and MESP Coordinator), Paul Rennick (Project Geologist - MDA II), and Laurie McNeill (GSIS Operator - MDA II).

Rao Irrinki and Paul Rennick continued the computerization of drill-hole data on major metallic mineral deposits in New Brunswick. The available drill-hole information on the Restigouche and Captain North Extension (CNE) deposits has been entered into the computer. Several cross-sections and longitudinal sections have been generated for both of these deposits.

Fifty representative samples were collected from the CNE deposit. Both thin and polished sections were studied for the documentation of lithological units mapped by Stratabound Minerals Corporation.

Rao Irrinki, Laurie McNeill, and Paul Rennick completed the pilot project on the Geoscience Information System (GSIS). The project demonstrated the usefulness of the CARIS Geoscience Information System for the management of New Brunswick's mineral resources.

Rao Irrinki presented the following three talks: 1) in March, 1990, a talk entitled 'Geoscience Information System' was given at CIM, Fredericton Region; 2) in May, 1990, a talk on the Geoscience Information System was presented at a conference on NB Information Systems organized by the New Brunswick Department of Supply and Services; and 3) a talk entitled 'The Key Anacon Sulphide Deposit' was given in June, 1990, at the NBDNRE Base Metal Symposium, in Bathurst.

Rao Irrinki represented the Mineral Resources Division on the financial committee (standards committee), subcommittees (Mapping, Remote sensing, and GIS), and working groups (Terminology and feature, entity classification) related to geographic information (Figure 13).

Rao Irrinki, Shasta Abbott, and Greg Crouse produced an audiovisual cassette-slide show on 'Geoscience Information System and the Management of New Brunswick's Mineral Resources'. This slide show was presented to the public during Mining Week in June, 1990.

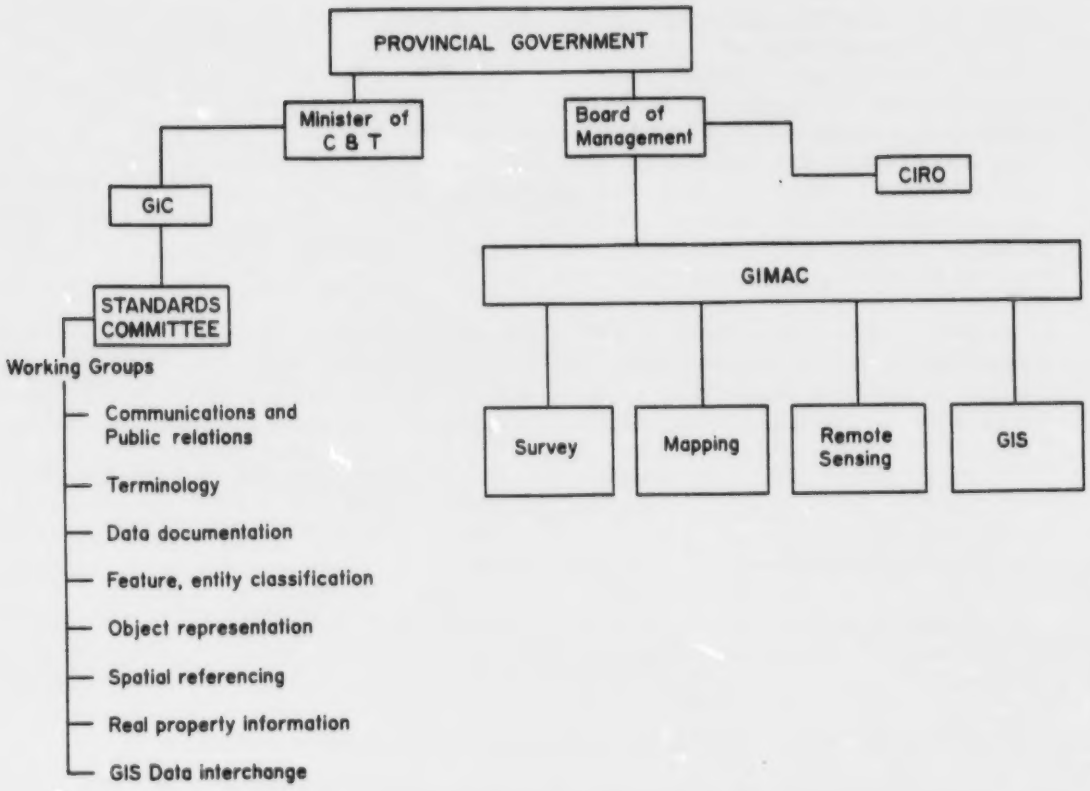

FIGURE 13. Provincial committees, subcommittees, and working groups related to geographic information.

Bill Gardiner compiled data on over 150 mineral occurrences and ground-checked sixty of them in the field. Twenty-nine mineral occurrences, exclusive of the Antinouri-Nicholas project area (Gardiner, Antinouri-Nicholas mineral occurrence study, this volume), were field-checked in 1990 in order to update the mineral occurrence file and to acquire representative samples for chemical analysis and thin-section preparation. Through researching current assessment files and other sources, an additional twenty-six mineral occurrences were recognized. As these are better documented, they will be added to the New Brunswick computerized mineral occurrence database. A display of representative samples from several deposits has been set up at the Ancillary Building. All samples will be archived for future reference.

Bill Gardiner provided informal consultation to prospectors and mineral exploration companies and conducted two introductory prospecting courses and one geochemical workshop. The prospecting courses were held in both Fredericton and Bathurst with both course locations being fully subscribed (45 participants). At least 15 additional people requested to take the course and

were put on a mailing list for next year. The introductory course consisted of 2 weekends (40 hours) of both classroom and field sessions. Instructors for the course were Don Hattie, Mark Connell, and Bill Gardiner. The Geochemical Workshop was also held over a weekend in September and constituted Part I of the Advanced Prospecting Course. This workshop consisted of a technical session, the workshop proper, and a field excursion to demonstrate the varied applications of geochemical prospecting. Instructors were Bill Coker (GSC), Toon Pronk, and Bill Gardiner.

As part of the 1990 International Association on the Genesis of Ore Deposits VIII Symposium, Bill Gardiner led a field trip that concentrated on mineral occurrences associated with the Burnthill Granite.

Paul Rennick has begun the compilation of geoscience data for parts of 21 P/12, 21 P/13, and 21 O/16. The data on three 1:20 000-scale maps (21 P/13d, 21 P/12e, and 21 O/16a) will be available at the end of this year.

Greg Crouse continued to coordinate the Mineral Exploration Stimulation Program (MESP) and update the drill-core and sample databases.

ACTIVITÉS DE LA SECTION DES GISEMENTS MINÉRAUX ET DU SIG

R.R. Irrinki, géologue senior

Le personnel de la section des gisements minéraux et du SIG comprend Rao Irrinki (géologue senior), Bill Gardiner (géologue - gites minéraux), Greg Crouse (responsable de la carothèque et coordonnateur du MESP), Paul Rennick (géologue de projet - EDM II), et Laurie McNeill (opératrice du SIGS - EDM II).

Rao Irrinki et Paul Rennick ont poursuivi l'informatisation des données de forage pour les principaux gisements minéraux métalliques du Nouveau-Brunswick. L'information disponible sur les trous des gisements de Restigouche et de Captain North Extension (CNE) a été informatisée. Plusieurs coupes transversales et longitudinales ont été produites pour les gisements de Restigouche et de CNE.

Cinquante échantillons représentatifs ont été recueillis sur le gisement de CNE. Des lames minces et des sections polies ont été étudiées afin de caractériser les unités lithologiques cartographiées par la Stratabound Minerals Corporation.

Rao Irrinki, Laurie McNeill, et Paul Rennick ont finalisé le projet-pilote sur le système d'information géoscientifique (SIGS). Le projet a démontré l'utilité du système d'information géoscientifique CARIS pour la gestion des ressources minérales du Nouveau-Brunswick.

Rao Irrinki a effectué les trois présentations suivantes : 1) en mars 1990, un exposé intitulé "Système d'information géoscientifique" a été fait à l'ICM, région de Fredericton; 2) en mai 1990, un exposé sur le système d'information géoscientifique a été fait lors d'une conférence portant sur les systèmes d'information de la province, organisée par le ministère de l'Approvisionnement et des Services du Nouveau-Brunswick; et 3) un exposé intitulé "Le gisement de sulfure de Key Anacon", fait en juin 1990 dans le cadre du symposium sur les métaux de base de la NBDNRE, à Bathurst.

Rao Irrinki a représenté la Division des ressources minérales sur le comité des finances (comité des standards), des sous-comités (cartographie, télédétection, et SIG), et des groupes de travail (terminologie et formes de relief, classification des entités) se rattachant à l'information géographique (Figure 13).

Rao Irrinki, Shasta Abbott et Greg Crouse ont produit un document audio-visuel sur cassette et diapositives portant sur le "Système d'information géoscientifique et la gestion des ressources minérales du Nouveau-Brunswick". Ce diaporama fut présenté au public lors de la semaine minière tenue en juin 1990.

Bill Gardiner a compilé les données sur plus de 150 indices minéralisés et en a vérifié soixante sur le terrain. Vingt-neuf indices minéralisés, excluant la région du projet d'Antinouri-Nicholas (Gardiner, Étude sur les indices minéralisés d'Antinouri-Nicholas, ce volume) furent vérifiés sur le terrain en 1990 de façon à mettre à jour le dossier sur les indices minéralisés et obtenir des échantillons représentatifs pour l'analyse chimique et la préparation des lames minces. Suite aux recherches dans les dossiers des travaux statutaires actuels et d'autres sources, vingt-six indices minéralisés additionnels furent identifiés. Comme ceux-ci sont mieux documentés, ils seront ajoutés au dossier des indices minéralisés du Nouveau-Brunswick. Un étalage d'échantillons représentatifs provenant de plusieurs gisements a été assemblé dans l'édifice auxiliaire. Tous les échantillons seront numérotés et classés en archives pour références futures.

Bill Gardiner a fourni des services de consultation informelle à des prospecteurs et des compagnies d'exploration minière, et a donné deux cours d'introduction à la prospection et un atelier sur la géochimie. Les cours de prospection furent tenus à Fredericton et à Bathurst, et aux deux endroits une participation maximum (45 participants) a été obtenue. Au moins quinze autres personnes ont demandé à suivre le cours et ont été inscrites sur une liste d'envoi pour l'an prochain. Le cours d'introduction comprenait deux fins de semaine (40 heures) partagées entre des cours en classe et des stages sur le terrain. Les instructeurs pour le cours furent Don Hattie,

Mark Connell et Bill Gardiner. L'atelier de géochimie fut aussi tenu une fin de semaine de septembre et constituait la première partie du cours de Prospection avancée. Cet atelier a compris une séance technique, l'atelier proprement dit, et une excursion sur le terrain visant à démontrer les diverses applications de la prospection géochimique. Les instructeurs furent Bill Coker (CGC), Toon Pronk et Bill Gardiner.

Dans le cadre du Huitième symposium (1990) de l'Association internationale sur la genèse des gisements métallifères (IAGOD), Bill Gardiner a dirigé une excursion sur le terrain qui porta sur les indices minéralisés associés au granite de Burnthill.

Paul Rennick a entrepris la compilation des données géoscientifiques sur des portions des cartes 21 P/12, 21 P/13 et 21 O/16. Les données sur trois cartes au 1:20 000 (21 P/13d, 21 P/12e et 21 O16a) seront disponibles vers la fin de cette année.

Greg Crouse a poursuivi la coordination du programme de stimulation de l'exploration minière (PSEM) et la mise à jour des banques de carottes de forage et d'échantillons.

GEOSCIENCE INFORMATION SYSTEM (GSIS) AND THE MANAGEMENT OF NEW BRUNSWICK MINERAL RESOURCES (MDA)

R.R. Irrinki, Senior Geologist

The Geoscience Information System (GSIS) pilot project began in June, 1989 and was successfully completed in September, 1990. It has demonstrated the usefulness of CARIS for the management of New Brunswick's mineral resources. This system is particularly valuable for customizing and creating digital base maps for maintenance of geological, geophysical, geochemical and mineral deposit data; and in the management of claims, leases, gravel pits, and reclamation areas. The digital geoscience data for 21 O/8 map area will be available to the public in various formats such as NTX (CARIS), DXF (Auto cad), Digital Line Graph (DLG), and Standard Interchange Format (SIF).

Le projet-pilote visant l'implantation d'un système d'information géoscientifique (SIGS) débute en juin 1989 et s'est terminé avec succès en septembre 1990. Le projet a démontré l'utilité de CARIS pour la gestion des ressources minérales du Nouveau-Brunswick. Ce système est particulièrement utile pour adapter et créer des fonds de carte numériques pour la mise à jour des données géologiques, géophysiques et géochimiques, et des gisements minéralisés; ainsi que pour la gestion des claims, des baux, des gravières, et des espaces réaménagés. Les données numériques géoscientifiques pour la carte 21 O/8 seront disponibles au public sous diverses formes telles que NTX (CARIS), DXF (Autocad), des graphiques linéaires numériques (DLG), et le format d'échange standard (SIF).

Geographic Information Systems (GIS) are now widely used for the management of natural resources. The Timber Management Branch of the New Bruswick Department of Natural Resources and Energy has been using the ARC/INFO Geographic Information System to manage the timber resource for the past ten years.

The Geoscience Information System (GSIS) is a combination of computer hardware and software that is capable of manipulating geoscience data, having both locational and non-locational attributes. It represents the Geographic Information System (GIS) for geoscience needs. An important role of the GSIS is data management. Large quantities of geoscience data must be manipulated and integrated in a safe and efficient manner.

In 1988, the Geological Surveys Branch recognized the need for a Geographic Information System for three main reasons: base-map maintenance; geoscience data compilation; and geoscience data integration. The Branch then submitted a proposal to the Mineral Resources Division for a GIS Pilot Project. The Division approved the project and provided $150 000 funding through the Canada-New Brunswick Mineral Development Agreement. Using this as base funding, the Mineral Resources Division approached the Department of Commerce and

Technology for additional funding in the amount of $225 000. This funding was provided for the purchase of GIS hardware and consulting fees to customize the CARIS (Computer-Aided Resource Information System) software for geoscience needs. The Department of Commerce and Technology promotes the locally developed CARIS software marketed by Universal Systems Ltd. of Fredericton.

The Pilot Project is defined as the customization of CARIS software for the Geoscience Information System. The purpose of this project is to evaluate the potential of GIS techniques for the management of New Brunswick mineral resources.

The California Lake (21 O/8) area was chosen for the Pilot Project (Figure 14). It is one of 90 - 1:50 000 National Topographic System map areas within New Brunswick. Each 1:50 000 map area is divided into 25 - 1:10 000 map areas. This NTS map area was chosen because of the availability of LRIS standard 1:10 000 digital base maps, pre-plotted assessment data, and the presence of numerous geoscience data sets.

The hardware configuration of the system consists of one SPARC 370 SERVER with 32 megabytes of memory and 1.5 gigabytes of hard-disk storage, one SUN 4 workstation with 16 megabytes of memory and 700 megabytes of hard-disk storage, two 19" colour monitors, one E-size pen plotter, one E-size digitizer, one USL controller, and one Tektronics screen dump (Figure 15). UNIX is the operating system for the hardware; CARIS is the GIS software and is used to manage the graphic database; and INGRES is the alphanumeric database that is used for attribute data management.

CUSTOMIZATION OF DIGITAL BASE MAPS

The Geological Surveys Branch staff use base maps ranging in scale from 1:5000 to 1:500 000. Traditionally, hard copies of the maps at scales of 1" = 20 chains and 1" = 40 chains have been obtained from NBDNRE Map and Photo Sales; 1:50 000 and 1:250 000 from Energy, Mines and Resources, Ottawa. In order to maintain a geoscience database at 1:20 000 scale for most parts of New Brunswick, and 1:10 000 where the data are warranted, the Geological Surveys Branch was forced to find an alternate source for these base maps.

The Geological Surveys Branch tried to produce 1:10 000 base maps by contracting them out to LRIS (formerly MRMS). This approach cost the Branch $110 000 per NTS sheet. In order to cut costs, the Branch found three alternate sources for digital base maps.

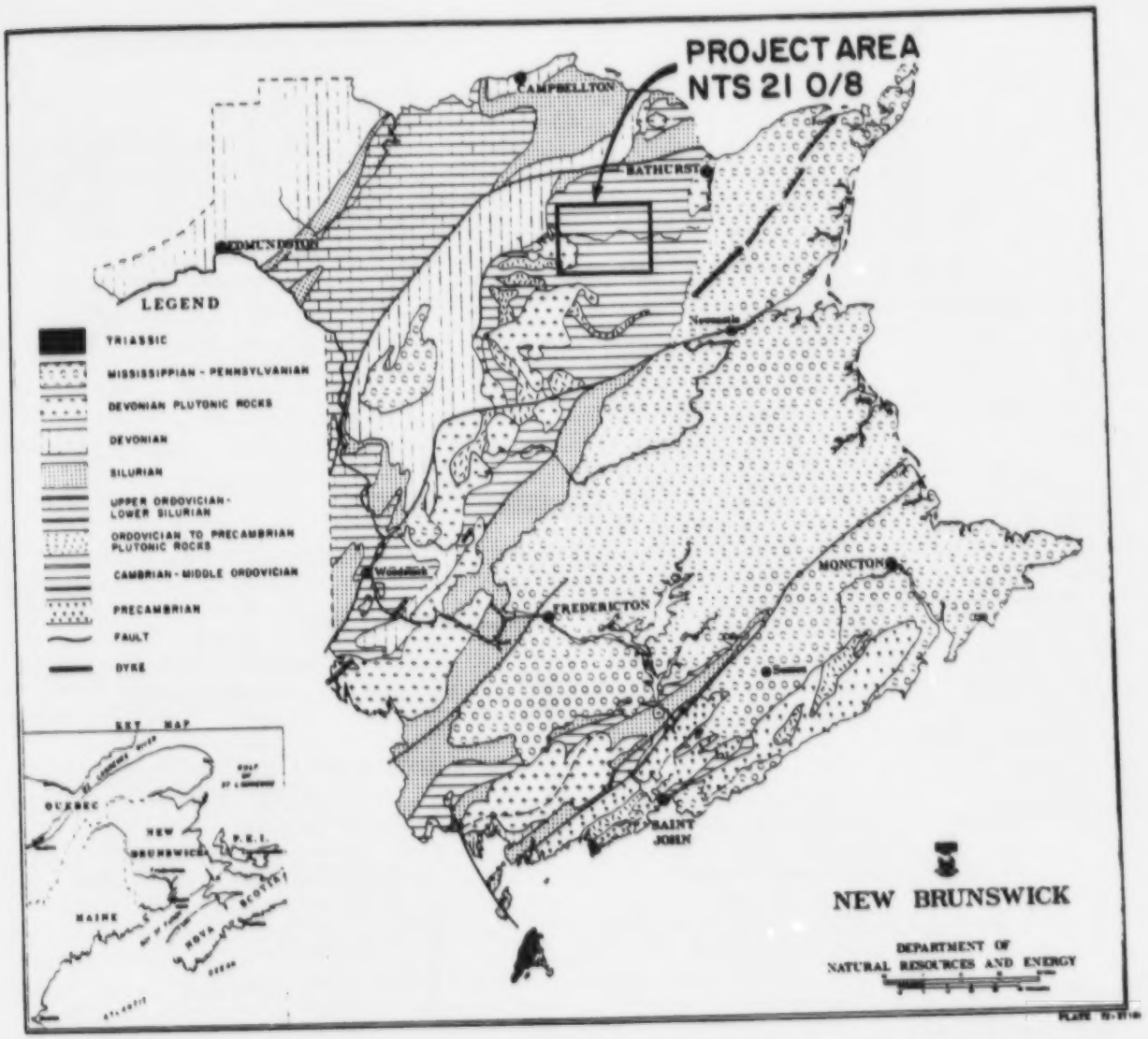

FIGURE 14. Index map showing the location of California Lake map area NTS 21 O/8 (pilot project).

LRIS has 1:10 000-scale digital base maps for 60% of New Brunswick with the remainder to be completed by 1993. The second source is the Timber Management Branch, which has complete coverage of the Province at 1:12 500 scale. The third source is Energy, Mines and Resources, which has complete coverage of New Brunswick at 1:250 000 scale and partial coverage at 1:50 000 scale. The cost of acquiring the digital base-map files from outside sources is $150 to $500/map file.

The digital base maps from LRIS, Timber Management, and EMR were manipulated and customized using CARIS. LANDSAT data were also used to update these base maps. Hard copies were produced at 1:10 000, 1:20 000, 1:50 000, and 1:250 000 scale.

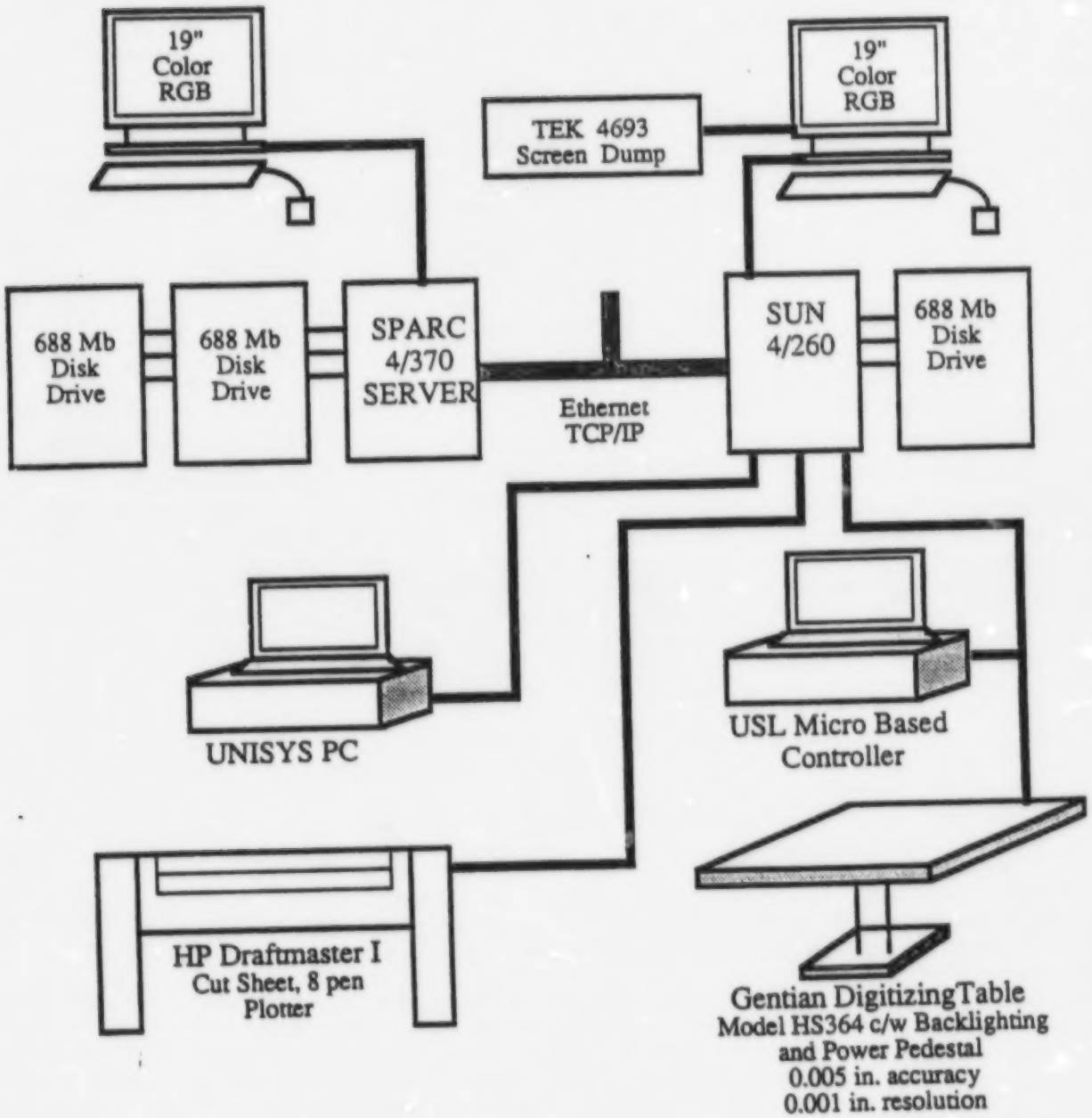

FIGURE 15. CARIS Hardware configuration.

GEOSCIENCE DATA COMPILATION

One of the priorities of the Mineral Resources Division is to present all the geoscientific information available in the assessment files, which are submitted by mining companies and prospectors to describe the work done on their mineral claims. Because of the great amount of these data, manual treatment of this information is becoming more and more cumbersome, inefficient, and expensive. In order to use the information more effectively, the Geological Surveys Branch started to compile these data, beginning with NTS 21 O/8. This work was contracted out at a cost of $80 000. The data were published as 125 - 1:10 000 maps that include base, geology, geophysics, geochemistry, and annotation layers. Work-location maps at 1:50 000 scale were published as four maps consisting of the work done between 1950-59, 60-69, 70-79, and 80-present. This project was integrated with the GIS when it became available.

Geology, geophysics, geochemistry, annotation, and work-location maps were manually digitized by using CARIS. Feature codes and symbology were created for all the plotted features and symbols. Several graphic menus were designed for faster and easier digitization of geoscience data. Five database files (consisting of geology, geophysics, airborne geophysics, geochemistry, and drilling) were created in both dBASE and INGRES.

GEOLOGICAL DATA MAINTENANCE

The Geological Surveys Branch staff have been involved in the collection of geoscience data. The Branch manages a geoscientific database acquired over 50 years by itself, the Federal Government, academic institutions, exploration companies, and prospectors. These data are commonly published in hardcopy format. Only about 50% of the recorded data is actually presented in these publications.

The Geological Surveys Branch publishes geological maps at 1:15 840, 1:31 680, 1:50 000, and 1:250 0000 scales. In order to comply with the Branch policies, the data have to be transferred to 1:20 000 scale. The Geological Survey of Canada publishes their maps at 1:50 000 scale; these data have to be transferred to 1:20 000 scale for integration purposes. Manual conversion of geoscience data to 1:20 000 scale is not only expensive, but time-consuming.

The geoscience data available at various scales were integrated with the GIS system. Feature codes were created for all the rock formations in New Brunswick. Several database files associated with each rock exposure were maintained in dBASE and INGRES.

GEOPHYSICAL DATA MAINTENANCE

Geophysical data are gathered mainly by the Geological Survey of Canada and published as 1:50 000 maps. These data consist of airborne magnetics, airborne radiometrics, and airborne VLF. Gravity data are also available at wide intervals. Ground geophysical data are also available for various parts of New Brunswick.

The Geological Survey of Canada scanned airborne geophysical data. Ten layers of these data are converted to CARIS format. These layers consist of total-exposure radiometrics, total-count potassium, total-count uranium, total-count thorium, uranium/thorium ratios, uranium/potassium ratios, thorium/potassium ratios, total field magnetics, VLF (quadrature), and VLF total electric field.

Seven bands of LANDSAT 5 have been converted to CARIS format. These are TM1 (visible blue), TM2 (visible green), TM3 (visible red), TM4 (short-wave reflected infrared), TM5 (middle-wave reflected infrared), TM6 (thermal-infrared), and TM7 (long-wave reflected infrared).

These seventeen layers of geophysical and remote sensing data are incorporated into the Geoscience Information System.

GEOCHEMISTRY DATA MAINTENANCE

The Geological Surveys Branch and the Geological Survey of Canada collect samples of stream sediments, water, soil, till, and rock as part of geochemical exploration. The samples are then analysed for 20 to 30 elements such as copper, lead, zinc, and mercury. These data are published on geochemical map plates.

These geochemical data have been incorporated into the Geoscience Information System. Several dBASE and INGRES tables have been prepared for the management of the data.

MINERAL-OCCURRENCE DATA MAINTENANCE

The data on 800 mineral occurrences have been maintained by the New Brunswick Computerized Mineral Occurrence Database, which is managed by four dBASE files. These files for 21 O/8 have been converted to INGRES. Batch digitization of these occurrences was carried out by using UTM coordinates.

MINERAL-DEPOSIT DATA MAINTENANCE

Drill-hole data on several major deposits are presently managed by four dBASE files, which include information on location, deviation, assays, and geology. A special software package by Geostat Systems International Incorporated has been used to produce cross- and longitudinal sections, plans, histograms, and to estimate reserves from the drill-hole data.

The four databases have been converted to INGRES. The graphic files have been converted to CARIS in order to incorporate with the GIS.

MINING PLANS AND RECLAMATION DATA STORAGE

The Mineral Development Branch receives and stores mining and reclamation plans for all developing mines. The reclamation and mining plans submitted by Heath Steele Mines for their Heath Steele and Stratmat properties have been manually digitized and incorporated into the GIS system.

CLAIM-TRACKING SYSTEM

The Mineral Development Branch records mineral claims staked in the Province by using a claim-tracking system that is managed by dBASE programs. These claims are manually plotted on 1:50 000-scale maps and are frequently updated.

The claims for NTS 21 O/8 have been digitized and incorporated with the GIS System. The dBASE files have been converted to INGRES.

SAND AND GRAVEL PIT MANAGEMENT

The data on sand and gravel pits are managed by a database file using the WANG System. The location of each pit is manually plotted on 1" = 40 chain maps.

The locations of gravel pits within NTS 21 O/8 have been digitized and integrated into the GIS System.

GEOSCIENCE DATA INTEGRATION

The above digital data sets, consisting of base maps, compilation data, geology, geophysics, geochemistry, remote sensing, mineral occurrences, mineral deposits, mining, reclamation, sand and gravel, and mineral claims have been integrated into the Geoscience Information System. It is now possible to retrieve the data in various combinations (Figure 16). The required layers would then be plotted with the pen plotter or by using the Tektronics screen dump.

SPATIAL ANALYSIS AND MODELLING

Spatial analyses involve combining data from multiple spatial data sets and performing spatial analysis techniques and modelling on the GIS data sets to transform data into information suitable for a given purpose. For example, if an exploration company is looking for exploration targets, the data sets should contain geology, geophysics, geochemistry, mineral occurrences, and assessment data layers. Each data set will be weighted in comparison to the others, with the resulting data providing the target areas.

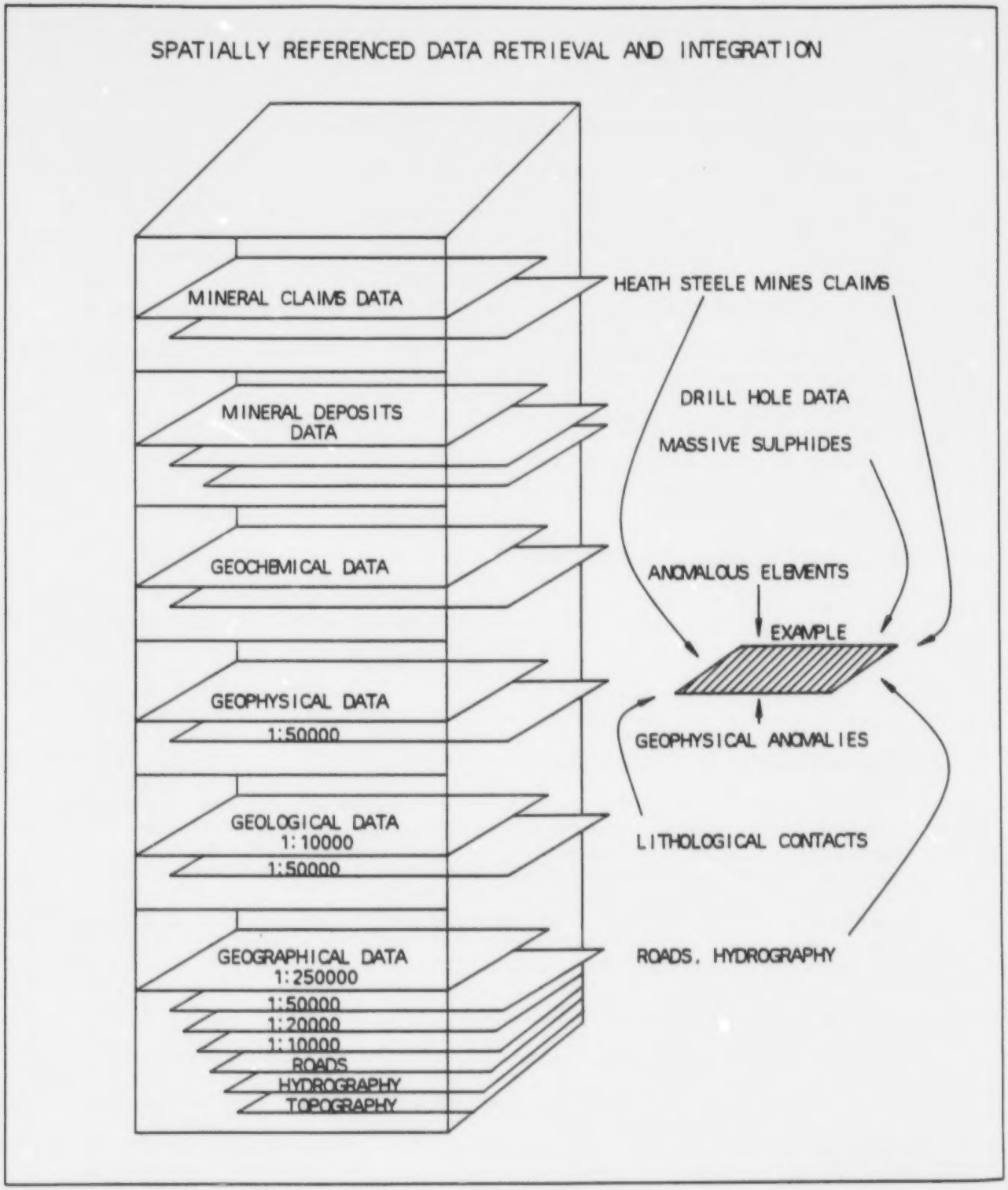

FIGURE 16. Schematic representation of Geoscience Information System.

CONCLUSION

The Geoscience Information System Pilot Project is successful. It has demonstrated the usefulness of the CARIS Geoscience Information System for the management of New Brunswick Mineral Resources. These data will be released to the public in various graphics exchange formats such as NTX (CARIS), DXF (AutoCAD), Digital Line Graph (DLG) and Standard Interchange Format (SIF). The Pilot Project is further expanded to include management of the Canada-New Brunswick Cooperation Agreement on Mineral Development (MDA II: 1990-95) data. During the next five years, geological data will be gradually integrated into the Geoscience Information System.

PRELIMINARY INVESTIGATION OF COTICULE OCCURRENCES IN NEW BRUNSWICK: THEIR USE IN EXPLORATION FOR MASSIVE SULPHIDE, TUNGSTEN, AND GOLD DEPOSITS (PROV)

W.W. Gardiner, Mineral Deposits Geologist

Coticules are manganiferous quartzites rich in spessartine garnet. They represent metamorphosed manganese-rich sediments, which are commonly exhalative in origin. Coticules have been recorded throughout the Appalachian-Caledonian orogen in rocks of Lower Paleozoic (generally Lower Ordovician) age. They do, however, occur throughout the world and at various stratigraphic ages. Recently, there has been an increasing amount of research indicating that the formation of coticules (along with their associated rock types such as tourmalinites) may be related to the formation of massive sulphide, stratiform scheelite, and greywacke-hosted gold deposits. The best studied example of this is the Broken Hill base-metal deposit in Australia.

The coticule occurrences in New Brunswick are now being documented, both in the Tetagouche Group in the central and northern parts of the Province and in the Cookson Group in the southern part of the Province. They represent metamorphosed red manganiferous shale (RMS) that contains high levels of a number of trace metals (Sn, W, Au, As). They lie at approximately the same stratigraphic level (which may be time-transgressive) as the Brunswick base-metal horizon and may be facies equivalents of the massive sulphide deposits. Coticules (along with the RMS) provides a good marker horizon in the Tetagouche Group and provides a source of metals that can be remobilized by tectonic, hydrothermal or magmatic processes into more significant mineral deposits.

Les coticules sont des quartzites manganésés riches en grenat de spessartine. Ils représentent des sédiments métamorphisés riches en manganèse, communément d'origine exhalative. Des coticules ont été observés à travers toute l'orogénie calédonienne des Appalaches dans des roches d'âge paléozoique inférieur (généralement de l'ordovicien inférieur). Ils se retrouvent toutefois partout dans le monde et à des âges stratigraphiques variés. Récemment, il y a eu une quantité croissante de recherches indiquant que la formation de coticules (avec leurs types de roches associées telles les tourmalinites) pourrait être reliée à la formation de sulfures massifs, de scheelite stratiforme, et de dépôts aurifères provenant de grauwacke. L'exemple le mieux étudié est celui du gisement de métaux de base de Broken Hill en Australie.

La présence de coticules au Nouveau-Brunswick est en voie d'être documentée, tant dans le groupe de Tétagouche dans les parties centrale et septentrionale de la province que dans le groupe de Cookson dans le sud de la province. Ils représentent des shales rouges manganésés métamorphisés (SRM) contenant de grandes quantités d'éléments-traces (Sn, W, Au, As). Ils reposent approximativement au même niveau stratigraphique (qui pourrait être transgressif dans le temps) que l'horizon de métaux de base de Brunswick, et pourraient être des faciès équivalents aux gisements de métaux de base. Les coticules (de même que les SRM) fournissent un horizon repère dans le groupe de Tétagouche et fournissent une source de métaux qui peut être remobilisée par des procédés tectoniques, hydrothermaux ou magmatiques en des gisements metallifères plus considérables.

COTICULES

Coticules, which are defined as manganiferous quartzites rich in spessartine garnet (Emerson 1898; Kennan 1986), represent metamorphosed manganiferous sediments (and locally manganese-rich mafic tuffs). Spessartine garnets can form at the lowest greenschist facies metamorphism, while their related tourmalinites may form at diagenetic conditions. Their recognition at lower metamorphic grades is more difficult than in the U.S. Appalachians where higher grade metamorphism has produced larger garnets. The garnets in New Brunswick are typically in the 0.1 to 1 mm size range and are typically overlooked in hand specimen. Coticules are certainly more difficult to recognize than their parent manganiferous sediments. Most of the occurrences documented in New Brunswick were not recognized until thin sections were made. Typically, the coticule horizons occur as pale pink to brown bands within quartzitic to tuffaceous horizons, generally stratigraphically above and within 100 metres of a basaltic flow or equivalent amphibolite.

The existing literature on coticules (and manganiferous sediments) indicates that they form mainly in two environments and are likely to develop on the same (possibly time-transgressive) stratigraphic horizon. The manganiferous sediments are deposited by slow chemical precipitation from sea-water so that large accumulations are restricted to periods of reduced clastic sedimentation. The manganese precipitates from sea-water (type 1) as a result of oxygenated water invading an anoxic environment; and from exhalative (hydrothermal) sources (type 2) associated with both ophiolite (ridge) and island-arc formation, where manganese precipitates in an oxygenated environment. The latter process can be subdivided into two related sub-processes: direct precipitation of manganese (type 2a) on the sea floor proximally and distally to the vent; and as an alteration of previously deposited clastics, volcanoclastics, and volcanics around and below the hydrothermal vent (type 2b). The former process (type 1) may ultimately derive its manganese from the latter (type 2) sources at great distance. Figure 17 shows the processes around a vent (typical of present-day vents), while Figure 18 shows the Ordovician record of manganese deposition that ultimately gave rise to the coticule horizons.

The coticules within the Meguma Group of Nova Scotia show no direct stratigraphic relationship to mafic volcanics. These coticules are thought to be derived directly from sea water (A. Sangster, personal communication) when oxygenated bottom currents, possibly derived from polar ice caps, invades anoxic waters and hence would be type 1. Anoxic water can contain a significantly higher concentration of Mn than oxic waters. The zone of mixing of the two waters creates a zone of active manganese precipitation. The coticules of the Meguma were formed as these waters flowed over a shelf/slope environment

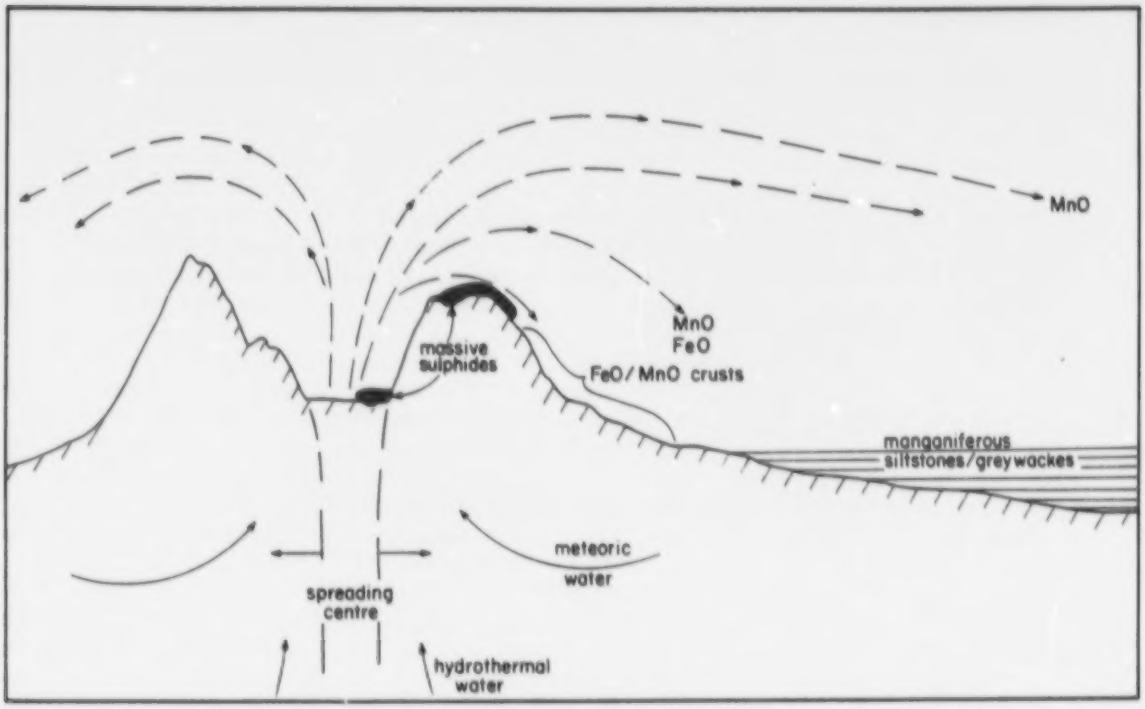

FIGURE 17. Present-day analogue for formation of manganiferous sediments at a spreading centre.

with sporadic clastic sedimentation. A continuation of this water onto the abyssal plain should result in the formation of precipitates analogous to the manganese nodules presently forming.

Both the Tetagouche and Cookson (Ludman 1987) coticule horizons in the New Brun-wick-Maine Appalachians generally occur above mafic volcanic flows and are most likely to derive their manganese from exhalative sources or from the breakdown of manganiferous mafic tuffs. The sediments in central New Brunswick were derived from the Lower Tetagouche volcanics on the northwest edge of the Paleozoic Iapetus Ocean in back-arc and fore-arc situations. The sediments in southern New Brunswick are presumably derived from the Avalonian terrane on the opposite side of Iapetus. The coticule horizons are not readily identifiable in hand specimen or outcrop scale. They are actually zones up to approximately 100 metres thick in which local beds, 1-100 cm in thickness, may contain upward of 80% spessartine garnet. Most of the beds in the zone may actually be devoid of garnets or contain only a few per cent spessartine. The more distal the coticule horizon from the hydrothermal vent, the thinner will be the garnetiferous sequence, and the more diffuse if some clastic sedimentary processes are ongoing.

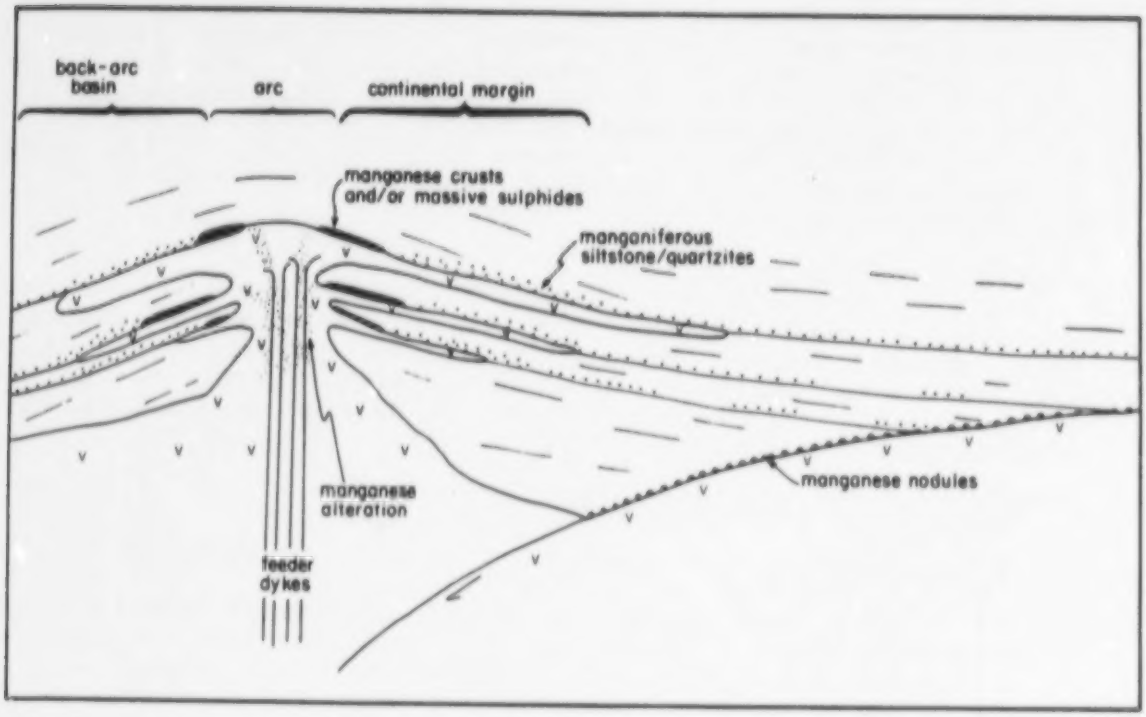

FIGURE 18. Distribution of manganiferous sediments in the Tetagouche Group of central New Brunswick.

CHEMISTRY

Manganese and manganiferous sediments are noted scavengers of metallic ions in solution in waters flowing over them. Consequently, manganiferous sediments should be enriched in many metals relative to purely clastic sediments. In the literature, coticules (and tourmalinites) show a distinct relationship to, if not enrichment in, precipitation of gold, tungsten, bismuth, and tin from exhalative sources. Hattie and Connell (personal communication, 1990) have just recently documented anomalous but highly variable trace-metal contents in the red manganiferous shale (RMS) horizon throughout the Tetagouche Group in the area between Woodstock and Bathurst. This horizon, when metamorphosed, gives rise to the coticules. Hattie and Connell also sampled a few New Brunswick coticules and found them to have elevated trace-metal contents.

In the non-metamorphic case, massive sulphide deposits may grade laterally and/or vertically into an iron-formation, which in turn may grade into manganiferous iron-formation and eventually into manganese formation. This is a function of the relative mobilities of the iron and manganese ions in solution in the sea water. This same gradation can be observed in the metamorphic case in the central New Brunswick Tetagouche Group rocks. Microprobe analyses of spessartines from 11 of 24

coticule occurrences in central New Brunswick indicate that the spessartines most closely associated with mafic flows, and hence more proximal to an exhalative source, are low in MnO (10.77-22.77%) and high in FeO (16.45-26.85%), while the more distal occurrences are high in MnO (29.58-31.80%) and low in FeO (5.0-9.69%). Figure 19 shows the coticule and RMS occurrences in central New Brunswick and the MnO contents of the spessartines analysed.

RELATED LITHOLOGIES

Besides tourmalinites, coticules may be closely associated with several other exhalative-derived lithologies. These include rocks enriched in rhodochrosite, fuchsite, gahnite (zinc spinel), zincian staurolite, as well as the more obvious massive sulphide deposits.

MINERAL DEPOSITS AND COTICULES

A coticule-package enveloping a massive sulphide deposit has been recognized at Broken Hill (Plimer 1976; Spry and Wonder 1989). This package probably represents exhalites and alteration haloes of pre-, syn- and post-massive sulphide age of formation. Laterally, the massive sulphide deposit grades into a coticule horizon, probably representing a lateral facies change. This in turn grades into a tourmalinite horizon. Both coticules and tourmalinites are documented as massive sulphide associates throughout the U.S. Appalachians (Kennan and Kennedy 1983; Taylor and Slack 1984), and more recently in western Newfoundland (O'Neill and Strong 1988). Data are currently being collected in the Tetagouche Group of the Bathurst area to determine the exact relationship of the coticule horizon to the massive sulphide deposits.

The study in central New Brunswick shows a distinct spatial association of the coticule-RMS horizon with several minor base-metal occurrences as well as many of the tin-tungsten-molybdenum deposits in the area. Plimer (1980) has also noted the relationship between coticules and tin-tungsten deposits of magmatic affiliation. Investigation of this association will be part of the ongoing study.

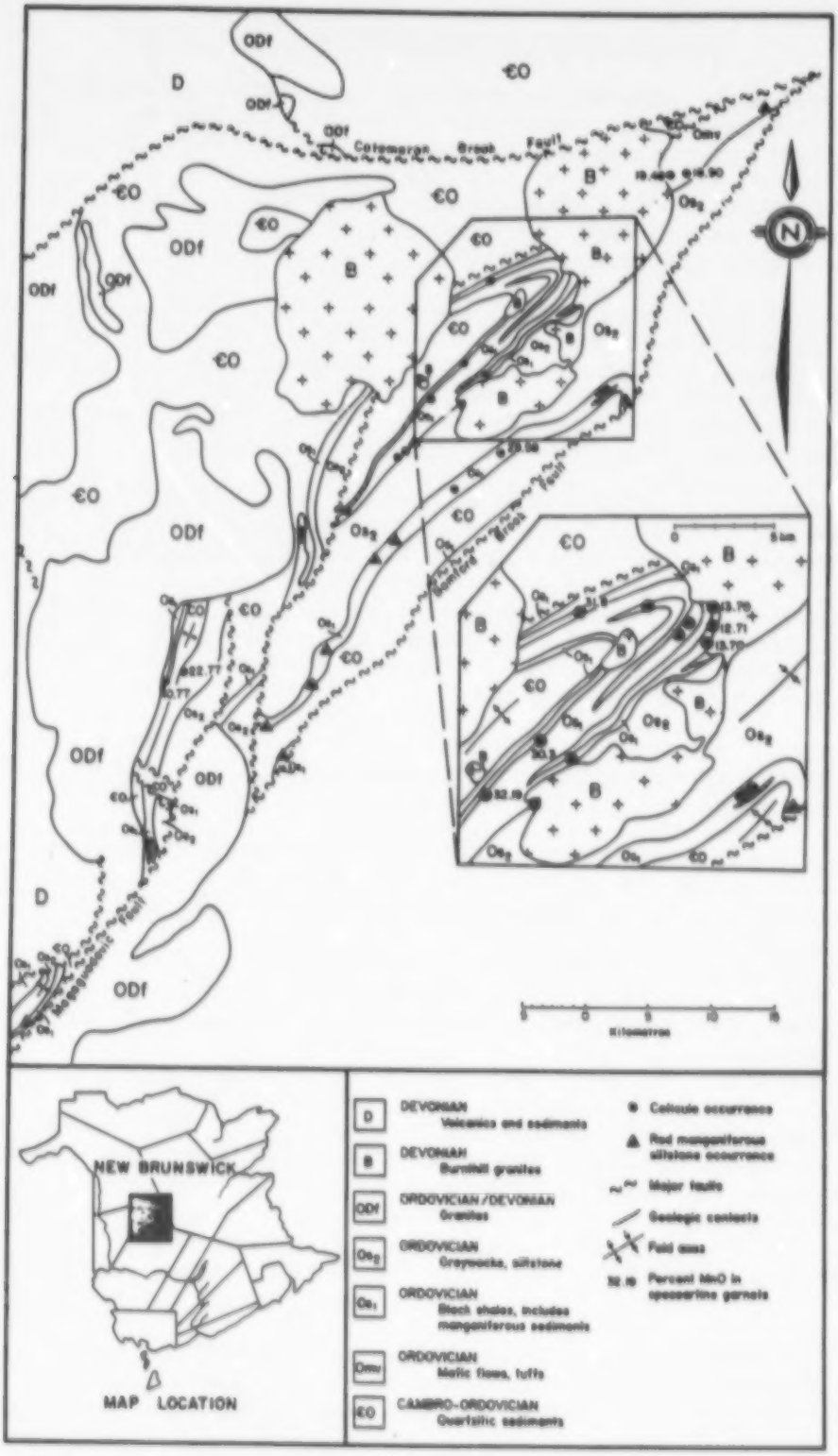

FIGURE 19. Coticule and RMS occurrences in central New Brunswick with MnO contents of spessartines.

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DRILL-CORE MANAGEMENT PROGRAM (PROV)

G.W. Crouse, Drill-core Manager

Approximately 19 000 metres of core was collected by New Brunswick Department of Natural Resources and Energy staff this year. Most of the core was collected from Mount Pleasant and surrounding areas and stored at the Sussex Regional Office.

Drill core in the Fredericton and Sussex facilities was reorganized and an inventory of the Madran core-storage facility was carried out. Drilling activity appears to be lower this year, but there have been more requests to view and sample the core stored by the Province. Information is still being added to the computer database on the drill core that the Province stores. Core logging and sample preparation laboratories located at Fredericton, Sussex, and Bathurst are being used extensively by exploration company personnel and Mineral Resources staff.

A rock-sample database was created for approximately 22 000 samples that have been collected by NBDNRE geologists over several years.

PROGRAMME DE GESTION DES CAROTTES DE FORAGE (PROV)

G.W. Crouse, responsable de la carothèque

Environ 19 000 mètres de carottes de forage ont été recueillies cette année par le personnel du ministère des Ressources naturelles et de l'Énergie. La majeure partie des carottes ont été prélevées à Mount Pleasant et dans les environs et sont entreposées au bureau régional de Sussex.

On a procédé au reclassement des carottes entreposées aux bureaux de Fredericton et de Sussex et on a effectué l'inventaire de la carothèque de Madran. Les activités de forage ont été à la baisse cette année, mais on a enregistré un accroissement des demandes d'examen des échantillons conservés par la province. Les laboratoires de diagraphie et de préparation d'échantillons de Fredericton, Sussex, et Bathurst sont régulièrement utilisés par le personnel des sociétés d'exploration et du ministère.

Une base de donnée des échantillons de roche a été créé afin de faciliter la consultation des quelque 22 000 échantillons recueillis par les géologues du ministère au cours des ans.

MINERAL EXPLORATION STIMULATION PROGRAM (MESP): (PROV)

G.W. Crouse, MESP Coordinator

The Mineral Exploration Stimulation Program (MESP) provides financial assistance to mineral exploration companies and prospectors who would like to carry out exploration for minerals within the Province of New Brunswick.

MESP is a direct private sector assistance program offered by the New Brunswick Department of Natural Resources and Energy. The program was first offered in 1988 and due to the popularity of the program was continued last year and again this year.

A committee of government and private sector representatives reviews applications for MESP grants and, if approved, up to $3 000.00 per prospector is available. The committee members are W.W. Gardiner, L.R. Fyffe, A.A. Ruitenberg, S.R. McCutcheon, D. Hoy, and G.W. Crouse. Eligible work would include: regional and detailed prospecting, grid establishment, geological mapping, geophysical and geochemical surveys, trenching and drilling, assays and chemical analysis, and specialized work such as mineralogy.

The committee reviewed 29 applications and approved 27 for funding, amounting to $81 000.00 for the 1990 fiscal year. MESP funds were also used to finance prospecting and advanced prospecting courses that were held in Fredericton and Bathurst in September and October, 1990.

PROGRAMME DE STIMULATION DE L'EXPLORATION MINIÈRE (PSEM): (PROV)

G.W. Crouse, coordonnateur de PSEM

Le programme de stimulation de l'exploration minière (PSEM) a pour mandat de fournir une aide financière aux sociétés d'exploration minière et aux prospecteurs qui désirent effectuer de la prospection au Nouveau-Brunswick.

Le PSEM est un programme d'aide directe au secteur privé offert par le ministère des Ressources naturelles et de l'Énergie du Nouveau-Brunswick. Ce programme, mis sur pied en 1988, s'est révélé tellement populaire qu'on a décidé de le prolonger l'année dernière et encore une fois cette année.

Un comité composé de représentants du gouvernement et du secteur privé est chargé d'examiner les demandes d'aide financière. Le montant maximal des subventions accordées dans le cadre de ce programme est de 3 000 $. Siègent à ce comité MM. W.W. Gardiner, L.R. Fyffe, A.A. Ruitenberg, S.R. McCutcheon, D. Hoy, et G.W. Crouse. Les projets admissibles dans le cadre

de ce programme sont l'exploration régionale ou détaillée, les activités de quadrillage, les levés de cartes géologiques, les études géophysiques et géochimiques, les travaux de terrassement et de forage, les tests et les analyses chimiques ainsi que les travaux spécialisés comme la minéralogie.

Des 29 demandes reçues par le comité, 27 ont été approuvées aux fins de financement, ce qui représente une somme de 81 000 $ pour l'année financière 1990. Les fonds du programme ont également servis à financer les cours d'introduction à la prospection et de prospection avancée qui ont été offerts à Fredericton et à Bathurst en septembre et en octobre 1990.

GEOLOGICAL SURVEYS BRANCH

GEOSCIENTIFIC EDITORIAL SERVICES SECTION

ACTIVITIES OF THE GEOSCIENTIFIC EDITORIAL SERVICES SECTION

B.M.W. Carroll, Geoscience Editor

The Geoscientific Editorial Services Section includes the following staff members: Barbara M.W. Carroll (Geoscience Editor), Shasta A. Abbott (Assistant Geoscience Editor - MDA), and Kim O'Donnell (Report Typist - MDA).

The responsibility of this section is to edit all geoscientific reports and maps that are produced by or for the Mineral Resources Division.

Following is the list of reports and maps released by the Division in 1990.

ACTIVITÉS DE LA SECTION DES SERVICES D'ÉDITION DE L'INFORMATION GÉOSCIENTIFIQUE

B.M.W. Carroll, rédactrice en chef, géoscience

La Section des services d'édition de l'information géoscientifique comprend le personnel suivant: Barbara M.W. Carroll (rédactrice en chef, géoscience), Shasta A. Abbott (rédactrice en chef adjointe, géoscience - EEM), et Kim O'Donnell (dactylo - EEM).

Cette Section est chargée d'éditer tous les rapports et cartes géoscientifiques produits par ou pour la Division des ressources minérales.

On trouvera ci-dessous la liste des rapports et des cartes publiés par la Division en 1990.

PUBLICATIONS OF THE MINERAL RESOURCES DIVISION - 1990

MAP PUBLICATIONS (in numerical order)

NEW BRUNSWICK DEPARTMENT OF NATURAL RESOURCES AND ENERGY. 1972. Generalized geology of New Brunswick. (Revised, 1990). Mineral Resources, Plate 72-27.

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NOTES

GEOLOGICAL SURVEYS BRANCH

BATHURST REGIONAL OFFICE

ACTIVITIES OF THE BATHURST REGIONAL OFFICE

S.R. McCutcheon, Regional Geologist

The staff of the Bathurst Regional Office in 1990 included Steven McCutcheon (Regional Geologist), John Langton (Assistant Regional Geologist), Sharon McKinnon (Administrative Officer and Deputy Mining Recorder), André LeBlanc and Maurice Belland (Engineering Technicians). John Langton was hired in May to replace James MacIntosh who went on long-term disability pension in September, 1989. André LeBlanc returned to work in April after being on a one-year leave of absence; Kevin Smith, who had replaced him for the year, went with Caribou Mining. Mike Parkhill and James Walker are contract geologists responsible for projects funded through the Canada-New Brunswick Cooperation Agreement on Mineral Development (MDA II; 1990-1995). Nicole Cormier, Susan Gower, Shyann LeBlanc, David Bance, Gino Boudreau, and Michael Schriver were hired as summer personnel.

PROJECTS

The Antinouri-Nicholas project (MDA II) was conceived as a 5-year program to study the mineral occurrences/deposits in the vicinity of the Antinouri Lake, Nicholas Dénys, and Nigadoo intrusions, which lie to the northwest of Bathurst. This project is an integrated study consisting of several sub-projects or phases, three of which are underway. Other phases, e.g., geophysical studies, may have to be abandoned because of limited funding. Phase One, geological mapping, was begun last year (McCutcheon and Walker 1989) in map area 21 O/9h; J. Walker and S. Gower, assisted by S. LeBlanc and G. Boudreau, respectively, continued this year in map areas 21 O/16a and 21 P/13d (Walker et al., this volume). Phases Two and Three were also begun this year. Phase Two was started by Bill Gardiner and his work consisted of finding, sampling, and categorizing the various mineral occurrences in the map areas (Gardiner, Antinouri-Nicholas mineral occurrence study, this volume). Phase Three was started by Paul Rennick who began compiling all existing assessment data in the map areas (Rennick, this volume).

The Brunswick project (Prov.) is a volcanological and lithogeochemical study of Tetagouche Group rocks that overlie and underlie the "Brunswick horizon", with the objectives being to 1) define the internal stratigraphy of the felsic volcanic pile, 2) determine if there is one or more favourable horizons and 3) show its (their) distribution on 1:10 000-scale geological maps and sections. The project area ultimately will encompass most of 21 P/5W (Nepisiguit Falls), but began in the vicinity of the Brunswick No. 6 open-pit. The results of a pilot lithogeochemical study were reported last year (McCutcheon et al. 1989). This year, J. Langton, assisted by M. Schriver, did geological mapping in 21 P/5-101, 21 P/5-102, 21 P/5-201 and 21 P/5-202 (Langton and McCutcheon, this volume) an area that encompasses the CNE base-metal deposit.

M. Parkhill, assisted by D. Bance, began mapping the surficial geology of 21 O/8 (Parkhill, this volume) in conjunction with the Halfmile-Heath Steele project (MDA II), a new program started this year by Reg Wilson (this volume). If funds are available, similar work will be conducted over the other project areas.

DIAMOND-DRILL CORE

In 1990, five holes, totalling 979.3 m, were transported from on-site storage at the Heath Steele mine to Madran. Also, forty-four holes (approximately 3000 m) from the CNE base-metal deposit were taken to Madran.

OTHER ACTIVITIES

Samples were collected from a number of base-metal deposits and sent to the Research and Productivity Council (RPC) in Fredericton for microprobe analysis. The purpose is to compare the compositions of chlorite and sericite from one deposit to another to find out (a) if there are magnesium-rich chlorites that are associated with hydrothermal alteration, and (b) if sericite associated with hydrothermal alteration can be distinguished from sericite produced during regional metamorphism.

S. McCutcheon gave several talks at conferences during the year. A talk was given at the Atlantic Geoscience Society Annual Meeting in Wolfville entitled: "Two U-Pb ages from the Upsalquitch Forks area, northern New Brunswick: economic and tectonic implications". The abstract of this talk was published in Volume 26 of Atlantic Geology. Another talk entitled: "Volcanological setting of the Brunswick massive sulphide deposits, northern New Brunswick" was given at the Prospectors and Developers annual meeting in Toronto and at the 8th International Association on the Genesis of Ore Deposits (IAGOD) Symposium in Ottawa. "Base metal deposits of the Bathurst-Newcastle district: characteristics and depositional models" was a talk presented at the Base Metal Symposium in Bathurst, and another entitled: "Depositional settings of massive sulphide deposits in the Bathurst-Newcastle district, New Brunswick" was given at the CIM District I meeting in t. Johns, Nfld. The last two abstracts were published in the June and October issues, respectively, of the CIM Bulletin.

S. McCutcheon attended a workshop in Toronto, prior to the PDA convention, to discuss a national geological mapping program (NATMAP). He was part of the selection committee that reviewed applications for funding under the Mineral Exploration Stimulation Program (MESP), and the committee that chose the recipient of the Barlow Medal for the best geology paper published in the CIM Bulletin during 1989.

Field trips were made to mineral properties held by the following companies: Brunswick Mining & Smelting, Falconbridge, Noramco, NovaGold, and Stratabound Minerals. Ad hoc trips were provided for a number of company geologists, and formal trips were conducted as part of the Base Metal Symposium and IAGOD.

The Base Metal Symposium, held in Bathurst from June 10th-13th, was planned by the Geological Surveys Branch and the Prospectors and Developers Association. The staff at the Bathurst office organized the technical session and field trips whereas the PDA set up the core-shack and trade-show. S. McCutcheon was symposium chairman and organized the one-day speakers program. Many of the papers presented at the meeting will be published in a special issue of the CIM Bulletin in 1991. S.McKinnon adeptly handled all the registration for the meeting and field trips. A. LeBlanc looked after technical services at the meeting and saw that everybody was well fed on the field trips.

S. McKinnon, A. LeBlanc, and M. Belland provided support services to explorationists and the geological staff in their usual efficient manner. It is notable that in 1990, S. McKinnon was given official authority to record, rather than just receive, mineral claims. This is a positive step since the majority of claims recorded in the Province are processed through the Bathurst office. A. LeBlanc spent considerable time keeping track of claim-regroupings, a common practice these days, and went to inspect some claims where over-staking had occurred.

ACTIVITÉS DU BUREAU RÉGIONAL DE BATHURST

S.R. McCutcheon, géologue régional

Le personnel du bureau régional de Bathurst comprenait, en 1990, Steven McCutcheon (géologue régional), Sharon McKinnon (agente administrative et archiviste adjointe), André LeBlanc et Maurice Belland (techniciens en travaux de génie). John Langton a été embauché en mai pour remplacer James MacIntosh, en pension d'invalidité à long terme depuis septembre 1989. André LeBlanc est revenu à son poste après un congé sabbatique d'un an; Kevin Smith, qui l'avait remplacé pendant un an, s'est joint à Caribou Mining. Mike Parkhill et James Walker sont des géologues contractuels, responsables des projets financés par l'entremise de l'entente de coopération Canada - Nouveau-Brunswick sur le développement minier (EDM II; 1990-1995). Nicole Cormier, Susan Gower, Shyan LeBlanc, David Bance, Gino Boudreau et Michael Schriver furent embauchés comme personnel d'été.

PROJETS

Le projet d'Antinouri-Nicholas (EDM II) fut conçu comme programme quinquennal visant à étudier les indices et gîtes minéralisés au voisinage du lac Antinouri, de Nicholas Dénys, et des intrusions de Nigadoo qui se trouvent au nord-ouest de Bathurst. Ce projet est une étude intégrée comprenant plusieurs sous-projets ou phases, dont trois sont en cours. D'autres phases, comme les études géophysiques, pourraient avoir à être abandonnées à cause de restrictions budgétaires. La phase I, cartographie, a débuté l'année dernière (McCutcheon et Walker 1989) dans la région de la carte 21 O/9h; cette année, J. Walker et S. Gower, assistés respectivement de S. LeBlanc et G. Boudreau, ont poursuivi cette première phase dans la région des cartes 21 O/16a et 21 P/13d (Walker et autres, ce volume). Les phases II et III furent aussi entreprises cette année. La phase II fut initiée par Bill Gardiner et son travail a compris la recherche, l'échantillonnage et le classement des divers indices minéralisés situés dans les régions de ces cartes (Gardiner, Étude des indices minéralisés d'Antinouri-Nicholas Dénys, ce volume). La phase III fut initiée par Paul Rennick qui a entrepris la compilation de toutes les données des travaux statutaires situés dans ces régions (Rennick, ce volume).

Le projet Brunswick (provincial) est une étude volcanologique et lithogéochimique des roches du groupe de Tétagouche qui se trouvent au-dessus et au-dessous de l'"horizon de Brunswick". Les objectifs de l'étude étaient 1) de définir la stratigraphie de l'empilement volcanique felsique, 2) de déterminer s'il y a un ou plusieurs horizons favorables et 3) de montrer sa (leur) distribution sur les coupes et cartes géologiques au 1:10 000. Le projet a débuté dans la région de la mine à ciel ouvert de Brunswick n° 6 et couvrira l'ensemble de la carte 21 P/5w (Nepisiguit Falls). Les résultats d'une étude-pilote lithogéochimique ont été rapportés l'année dernière (McCutcheon et autres, 1989). Cette année, J. Langton, assisté de M. Schriver, a cartographié une portion des cartes 21 P/5-101, 21 P/5-102, 21 P/5-201 et 21 P/5-202 (Langton et McCutcheon, ce volume), soit une zone qui comprend le gisement de métaux de base de CNE.

M. Parkhill, assisté de D. Bance, a entrepris la cartographie des dépôts meubles de la carte 21 O/8 (Parkhill, ce volume) conjointement avec le projet de Halfmile-Heath Steele (EDM II), un nouveau programme entrepris cette année par Reg Wilson (Wilson, ce volume). Si des fonds sont disponibles, des travaux similaires seront entrepris dans les autres régions du projet.

CAROTTES DE FORAGE

En 1990, les carottes de cinq trous, totalisant 979,3 m, furent transportés de l'entrepôt de la mine Heath Steele à Madran. Les carottes de quarante-quatre trous (approximativement 3 000 m) provenant du gisement de métaux de base de CNE furent aussi transportés à Madran.

AUTRES ACTIVITÉS

Des échantillons furent recueillis à partir de certains gisements de métaux de base et envoyés au Conseil de recherche et de productivité (CRP) à Fredericton pour des analyses à la microsonde. Le but est de comparer les compositions de la chlorite et de la séricite d'un gisement à l'autre, et de déterminer (a) s'il y a des chlorites riches en magnésium qui sont associées à l'altération hydrothermale, et (b) si la séricite associée à l'altération hydrothermale peut être distinguée de la séricite produite au cours du métamorphisme régional.

S.R. McCutcheon a fait plusieurs présentations lors de conférences tenues au cours de l'année. Un exposé a été fait à la rencontre annuelle de la Atlantic Geoscience Society à Wolfville intitulé : "Deux âges pour l'U-Pb de la région de Upsalquitch Forks, Nouveau-Brunswick septentrional : conséquences économique et tectonique". Le résumé de cet exposé a été publié dans le volume 26 de Atlantic Geology. Un autre exposé intitulé : "La mise en place volcanogénique du gisement de sulfures massifs de Brunswick, Nouveau-Brunswick septentrional" a été fait au congrès annuel du Prospectors and Developers à Toronto et au Huitième symposium de l'Association internationale sur la genèse des gisements métallifères (IAGOD) à Ottawa. Un autre exposé intitulé : "Les gisements de métaux de base du district de Bathurst-Newcastle : caractéristiques et modèles de formation" a été fait au symposium sur les métaux de base tenu à Bathurst, et un autre intitulé : "Les modes de mise en place des gisements de sulfures massifs dans le district de Bathurst-Newcastle, Nouveau-Brunswick" a été fait lors de la rencontre de l'ICM du district I à St. John's, Terre-Neuve. Les deux résumés furent publiés respectivement dans les numéros de juin et de septembre du journal de l'ICM.

S. McCutcheon a participé à un atelier à Toronto, avant le congrès du PDA, afin de discuter d'un programme de cartographie nationale (NATMAP). Il était membre du comité de sélection qui revisa les demandes de financement en rapport avec le programme de stimulation de l'exploration minière (PSEM), et du comité qui choisit le récipiendaire de la médaille Barlow, attibuée à l'auteur du meilleur article géologique publié dans le journal de l'ICM en 1989.

Des visites sur le terrain furent effectuées sur les propriétés minières des compagnies suivantes : Brunswick Mining & Smelting, Falconbridge, Noramco, NovaGold et Stratabound Minerals. Des excursions ad hoc furent effectuées pour des géologues d'entreprises privées, et des excursions formelles furent organisées en rapport avec le symposium sur les métaux de base et celui de l'IAGOD.

Le symposium sur les métaux de base, tenu à Bathurst du 10 au 13 juin, fut planifié par la Direction des études géologiques et le PDA. Le personnel du bureau de Bathurst organisa la séance technique et les visites sur le terrain alors que le PDA s'occupa de la carothèque et de la foire commerciale. S. McCutcheon a présidé le symposium et a organisé le programme de la journée des conférenciers. Plusieurs des exposés présentés au symposium seront publiés dans un numéro spécial du journal de l'ICM en 1991. S. McKinnon s'est occupé avec expertise de toutes les inscriptions pour la conférence et les visites sur le terrain. A. LeBlanc était responsable des services techniques à la conférence et a vu à ce que tous soient bien nourris lors des visites sur le terrain.

S. McKinnon, A. LeBlanc et M. Belland ont fourni, selon leur efficacité habituelle, les services de soutien au personnel d'exploration et de géologie. Il est à noter qu'en 1990, S. McKinnon a reçu l'autorité d'enregistrer officiellement, et non simplement de recevoir, les titres miniers. Ceci est une étape positive puisque la majorité des claims de la province sont traités par l'entremise du bureau de Bathurst. A. LeBlanc a passé un temps considérable à contrôler les groupes de claims, une procédure très populaire ces temps-ci, et est allé inspecter certains claims où le jallonnage était en conflit.

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SURFICIAL GEOLOGY AND TILL GEOCHEMISTRY OF THE CALIFORNIA LAKE MAP AREA (NTS 21 O/8), GLOUCESTER, NORTHUMBERLAND, AND RESTIGOUCHE COUNTIES, NEW BRUNSWICK (MDA)

M.A. Parkhill, Project Geologist

Surficial geology mapping at a scale of 1:50 000 was started during 1990 in the northern part of the California Lake map area (NTS 21 O/8). B-horizon soils, basal till and pebbles were sampled at 142 sites on a 2 km grid. Soil profile descriptions and vegetation inventories were prepared. The mapping and sampling will be completed in 1991. Samples will be analysed for gold plus 33 elements, and selected base metals.

Recording of over 387 striae, as well as grooves and roche moutonnée, mostly north of the Nepisiguit River, indicates that an early eastward ice movement was followed by northeastward- and southeastward-flowing ice. Minor late-stage, local ice flows in various directions followed throughout the area. A train of granite-boulder erratics in the northern part of the area indicates glacial transport of up to 30 km in an east-northeast direction from the Mount Elizabeth Intrusive Complex and the Popple Depot Granite.

Most of the area is covered by a thin layer of Late Wisconsinan basal till (approximately 1 - 2 m), which thickens in the eastern part of the map area where the topography is gently rolling.

The Nepisiguit and Northwest Miramichi river valleys, and other major rivers and brooks contain glaciofluvial, and post-glacial alluvial deposits. Bedrock and colluvium dominate in steep valleys and on mountains and ridges.

La cartographie de la géologie des dépôts meubles à l'échelle de 1:50 000 a été entreprise en 1990 dans la région septentrionale de la carte de California Lake (SNRC 21 O/8). Les sols de l'horizon-B, le till de fond et les cailloux furent échantillonnés en 142 sites selon une grille de 2 km. Des descriptions du profil pédologique et des inventaires de la végétation furent préparés. La cartographie et l'échantillonnage seront complétés en 1991. Les échantillons seront analysés pour l'or et 33 éléments, ainsi que pour certains métaux de base.

L'observation de plus de 387 stries, de même que de cannelures et de roches moutonnées, surtout au nord de la rivière Nepisiguit, indique un écoulement glaciaire récent vers l'est suivi d'un écoulement vers le nord-est et le sud-est. Quelques écoulements tardifs locaux selon diverses directions ont été observés un peu partout dans la région. Une dispersion de blocs erratiques granitiques dans la partie nord de la région indique un transport glaciaire à partir du complexe intrusif de Mount Elizabeth et du granit Popple Depot, allant jusqu'à 30 km dans la direction est-nord-est.

L'ensemble de la région est recouverte d'une mince couche de till de fond d'âge Wisconsin supérieur (approximativement 1 à 2 m), qui s'épaissit dans la partie orientale de la carte où la topographie est légèrement ondulante.

Les vallées fluviales de Nepisiguit et de Miramichi nord-ouest, ainsi que d'autres rivières et ruisseaux, contiennent des dépôts glaciofluviaux et des dépôts alluvionnaires post-glacials. Le socle rocheux et des colloïdes dominent dans les vallées à pentes raides et sur les montagnes et les crêtes.

INTRODUCTION

During the summer of 1990, a surficial mapping and till sampling (one sample per 4 km^2) program was started (1:50 000 scale), mainly in the northern part of the California Lake (NTS 21 O/8) map area. The California Lake map area lies in north-central New Brunswick, 60 km southwest of Bathurst along Route 430 and 60 km northwest of Newcastle along Route 430 (Figures 20 and 21). A total of 142 sites were sampled (pebbles, B- and C- horizons). In addition, vegetation inventories and soil-profile descriptions were recorded for forest-site classification purposes.

The California Lake area was selected for study because of its proximity to previously mapped areas (Figure 20), similarities in bedrock geology, favourability for mineral exploration, known mineral deposits, lack of coverage in previous till surveys, and simultaneous bedrock mapping by Reg Wilson (this volume) and Cees van Staal. The granular aggregate resources of the area were mapped during 1985 (Paradis et al. 1986). A till sampling survey was carried out in parts of the area from 1985-88 (Lamothe 1990). This project concentrates more on till mapping, grid sampling, and glacial history. David Bance assisted in the 1990 mapping and sampling.

PHYSIOGRAPHY

In the western part of the area, topography is strongly bedrock controlled with deeply incised v-shaped valleys and high mountains, including Mt. Acquin at 666 m above sea level. Toward the east, topography is gently rolling and hummocky with more u-shaped valleys and swamps. Local relief in the study area is up to 390 m.

BEDROCK GEOLOGY

The California Lake area is underlain by sedimentary rocks of the Cambro-Ordovician Miramichi Group; sedimentary and felsic and mafic volcanic rocks of the Ordovician Tetagouche Group and mafic volcanic and sedimentary rocks of the Ordovician Fournier Group (van Staal 1990). The southwestern corner of the map sheet is underlain by the Silurian Mount Elizabeth Intrusive Complex (Figure 21) as well as other Silurian and Ordovician mafic and felsic intrusive rocks (Whalen 1988). Many mineral deposits are situated in the California Lake area including; the Heath Steele, Stratmat, Halfmile Lake, Wedge, Devils Elbow, and Canoe Landing Lake deposits.

QUATERNARY GEOLOGY

The glacial history of the area is consistent with other areas mapped to the west (NTS 21 O/7; Parkhill, in preparation)

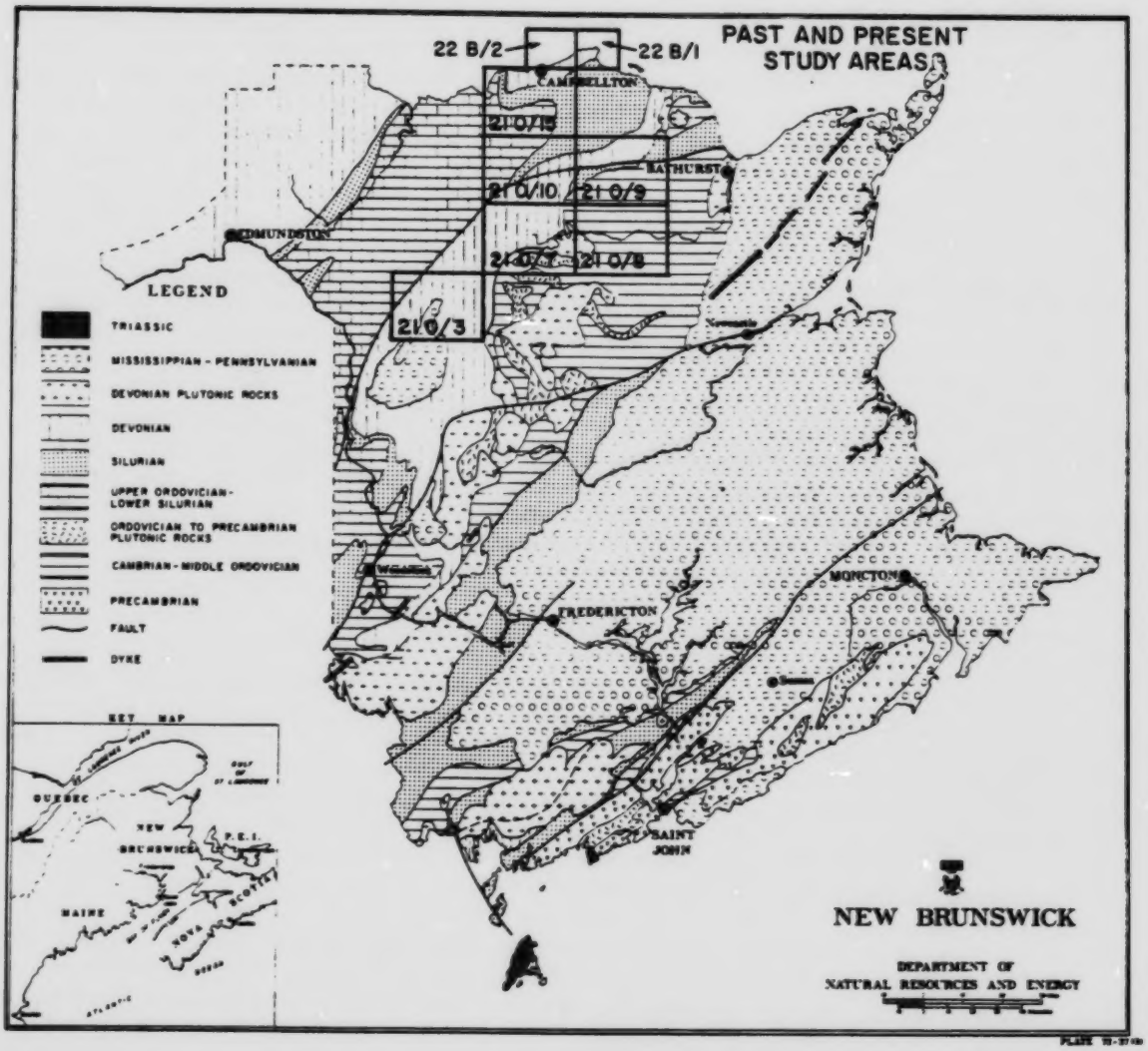

FIGURE 20. Location of Provincial surficial geology-till geochemistry projects in northern New Brunswick (1985-1990).

and to the north (NTS 21 O/9; Pronk 1986). Recording of over 387 striae and/or groove and roche moutonnée locations indicates a strongly erosive eastward ice movement (070°-105°) followed by northeastward- (035°-055°) and southeastward- (130°-150°) flowing ice. Minor late-stage ice, flowed in various directions from local topographic highs throughout the area. Striae are better preserved on mafic volcanic rocks that generally underlie gently rolling topographic lows. Striae are more dominant on westward-facing slopes (stoss) than on the down-ice slopes (lee).

A train of granite-boulder erratics, mapped in the northern and eastern parts of the area, indicates glacial transport of up to 30 km in an east-northeast direction from the source area in the Silurian Mount Elizabeth Intrusive Complex and the Ordovician Popple Depot Granite (Whalen 1988). Granite boulders found in the Nepisiguit River valley and in a large meltwater channel in the Canoe Landing Lake area were fluvially, as well as glacially, transported from the Mount Elizabeth Intrusive Complex and the Popple Depot Granite.

A generally thin (less than 2 m) layer of sandy/clayey greenish to yellowish brown basal till of Late Wisconsinan age covers most of the area. Basal till thickens in the eastern part of the area where topography is gently rolling and hummocky. Ablation till occurs as a thin lag deposit over basal till or as a thicker (greater than 2 m) deposit in some river and brook valleys.

In areas of high relief, and on the mountains and ridges that are mostly underlain by felsic volcanic and intrusive rocks, frost shattering and a lack of thick till deposits has created a layer of bouldery colluvium or rock veneer with small patches of thin basal till. Steep v-shaped valleys are generally covered with colluvial material, e.g., the upper reaches of Nepisiguit River valley.

Large, thick deposits of glaciofluvial outwash and ice-contact kames and eskers are found along the Nepisiquit River valley, with smaller deposits located in other rivers and brooks. Recent alluvial deposits also occur in many rivers and brooks (Figure 21).

Preliminary investigation of pebble samples from basal till indicate that the tills are generally locally derived (less than 2 km transport distance) with some distal transport of granite clasts of up to 30 km.

A 1:10 000-scale study of the surficial deposits and their geotechnical and geochemical properties will be conducted in the area of the Halfmile Lake mineral deposit. Approximately 25 samples will be taken on a 1 km grid.

Mapping and sampling in the California Lake area will be completed during the 1991 field season. The -250 mesh size fraction of the basal till (C-horizon) samples will be analysed for Au plus 33 elements and selected base metals. Pan concentrates on selected samples will be analysed in a comparison study. A Geological Notes Series report, useful for mineral exploration, forestry, and land-use planning applications, will be produced.

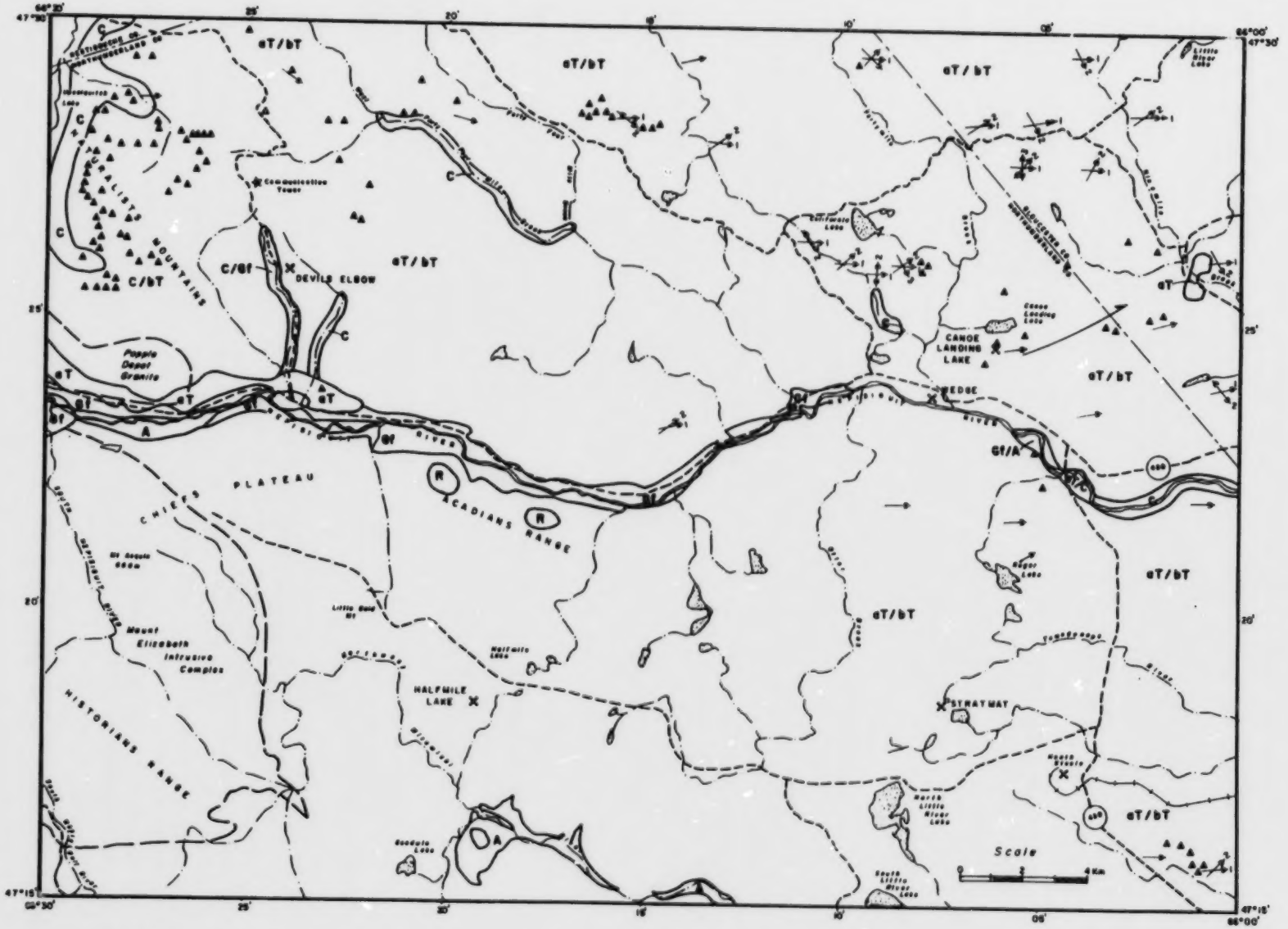

FIGURE 21. Preliminary surficial geology of California Lake map area (21 O/8).

Legend

AGE	UNIT	DEPOSIT
QUATERNARY		
HOLOCENE	C	Colluvial (minor patches of till)
	A	Alluvial (sand and gravel)
LATE WISCONSINAN	Glaciofluvial	
	Gf	Outwash and ice-contact (mainly sand and gravel, minor cobbles and boulders, may be stratified)
	Glacial	
	aT/bT	Morainal sediments (mainly basal till, minor ablation till and in places ablation lag over basal till; generally thin (<2m), greenish to yellowish brown, fine to coarse, sandy/gravelly to sandy/clayey/loamy tills).
PRE-QUATERNARY		
	R	Bedrock

Symbols

- Major access roads
- Train line
- Major rivers and streams
- Glacial striae (direction known, unknown)
- Relative age of striae (1) older, (2) younger
- Roche moutonnée
- Morphogenetic boundary
- ▲ Boulder erratic
- Meltwater channel
- Boundary of granite bedrock- (source area for boulder erratics)
- × Mineral deposit

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ANTINOURI-NICHOLAS PROJECT (MDA)

J. Walker, S. Gower, and S.R. McCutcheon

The Antinouri-Nicholas project comprises three subprojects; 1) 1:20 000 scale mapping, 2) mineral occurrence and/or deposit studies, and 3) compilation of assessment data.

Geological mapping of three map areas (21 O/9h, 21 O/16a, and 21 P/13d) has shown that there are Chaleurs Group rocks along the northwest margin of the Elmtree block. The oldest Chaleurs Group rocks are conglomerates and limestones (probably middle Silurian) that are overlain by mafic and felsic volcanic rocks. The boundary between the Chaleurs Group and overlying Lower Devonian Dalhousie Group is tentatively drawn at the top of a mafic volcanic unit that underlies the first fossiliferous Lower Devonian siltstones. Folding and sedimentation probably occurred simultaneously because there are folds in older parts of the Chaleurs Group that appear to be overstepped by younger strata. The area is also transected by several east- to northeast-trending faults, all of which show dextral offset. Within the Elmtree block, a tectonic mélange is widespread north of Antinouri Lake and a band of mafic volcanics, previously mapped as diabase dykes, occurs in the same area. The contact aureole of the Antinouri Lake Granite has been found to extend 1 to 1.5 km from the granite contact. A previously unrecognized quartz-feldspar-porphyritic phase of the intrusion has been mapped.

Le projet d'Antinouri-Nicholas comprend trois sous-projets : 1) une cartographie à l'échelle 1:20 000, 2) des études d'indices minéralisés et/ou de gisements minéraux et 3) la compilation des données géoscientifiques.

La cartographie des régions de trois cartes (21 O/9h, 21 O/16a et 21 P/13d) a montré qu'il y a des roches du groupe Chaleurs le long de la bordure du bloc d'Elmtree. Les roches du groupe Chaleurs les plus âgées sont des conglomérats et des calcaires (probablement du silurien moyen) qui se trouvent sur des roches volcaniques mafiques et felsiques. La frontière entre le groupe Chaleurs et le groupe Dalhousie sus-jacent, d'âge dévonien inférieur, est provisoirement placée à la base de l'unité volcanique mafique qui est sous-jacente aux premiers microgrès fossilifères du dévonien inférieur. Les plissements et la sédimentation ont probablement eut lieu simultanément car il y a des plis dans les parties plus âgées du groupe Chaleurs qui semblent être dépassés par des couches plus jeunes. De plus, cette zone est sectionnée par plusieurs failles de direction est et nord-est, montrant toutes un rejet dextre. À l'intérieur du bloc d'Elmtree, un mélange tectonique est répandu dans tout le nord du lac Antinouri, et une bande de volcanique mafique, précédemment cartographiée comme étant des dykes de diabase, se retrouve dans cette même région. L'auréole de contact du pluton granitique d'Antinouri Lake s'étend de 1 à 1,5 km en dehors du contact granitique. Une phase feldspath-porphyre de l'intrusion, précédemment inconnue, a été cartographiée.

The Antinouri-Nicholas project area lies northwest of Bathurst and encompasses the following 1:20 000 map areas: 21 P/12e,f; 21 P/13c,d,e,f; 21 O/9h; and 21 O/16a,h (Figure 22). The project includes several subprojects or phases:
1) 1:20 000-scale geological mapping with petrography and litho-geochemistry as required; 2) mineral occurrence/deposit studies;

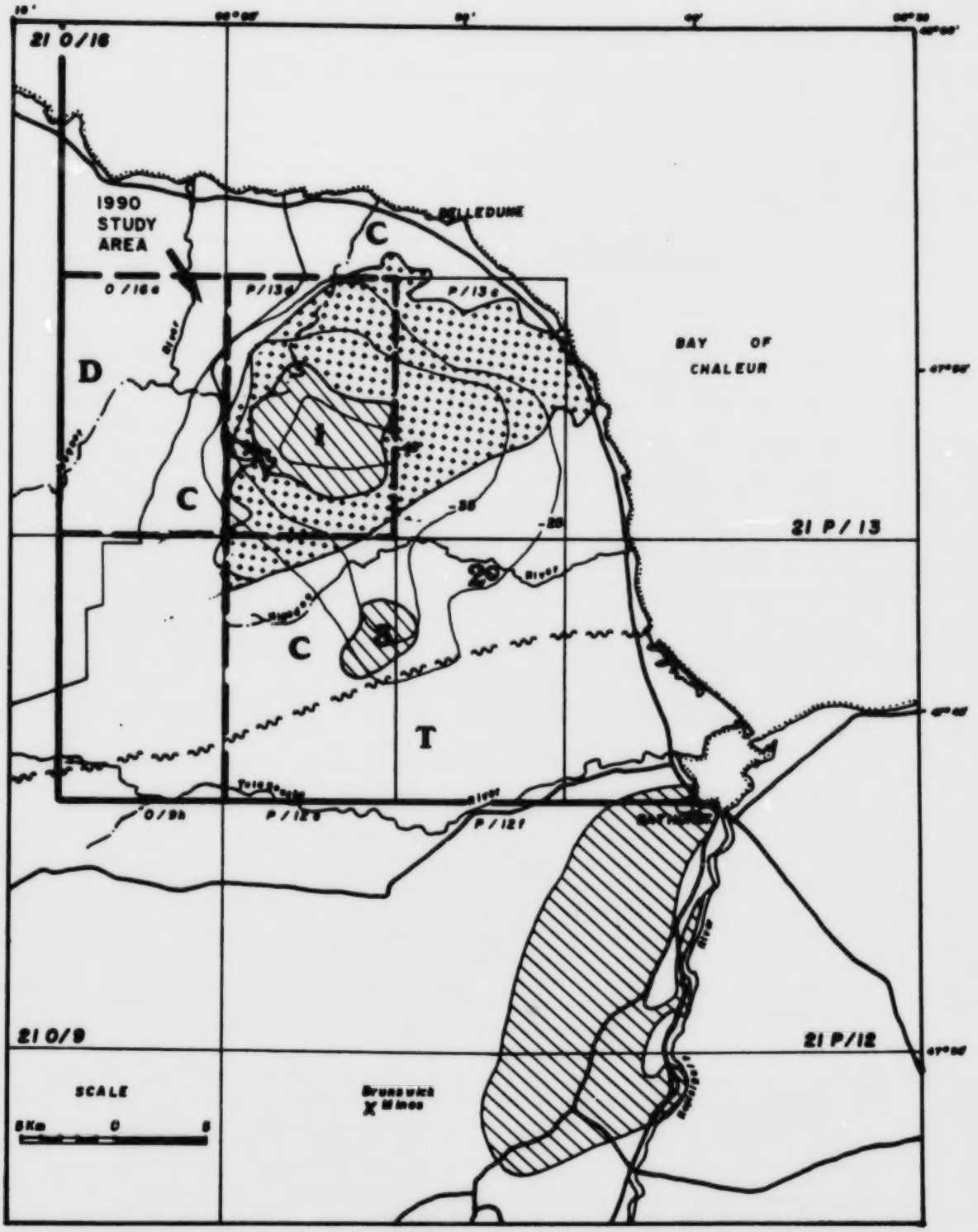
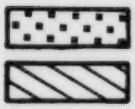


FIGURE 22. Index map to Antinouri-Nicholas project area.



ELMTREE TERRANE

FELSIC INTRUSIONS

1. Antinouri Lake

2. Nigadoo

3. Nicholas – Dénys

D DALHOUSIE GROUP (mainly)

C CHALEURS GROUP (mainly)

T TETAGOUCHE GROUP (mainly)

ROCKY BROOK-MILLSTREAM FAULT

-38 GRAVITY CONTOUR (milligals)

3) compilation of assessment data; 4) till mapping and geochemistry; 5) computerization of drill-hole data; and 6) enhancement of remotely sensed data.

Phase One of the project was started last year in the 1:20 000-scale map area 21 O/9h. This year, mapping was conducted by J. Walker and S. Gower (assisted by S. LeBlanc and G. Boudreau, respectively) in map areas 21 O/16a and 21 P/13d. Phases Two and Three were also begun this year. Phase Two was undertaken by W. Gardiner who relocated, sampled, and categorized the various mineral occurrences in the map area (Gardiner, Antinouri-Nicholas mineral occurrence study, this volume). Phase Three was started by P. Rennick who began compiling assessment data for the area (Rennick, this volume).

RESULTS OF 1990 MAPPING

The project area encompasses parts of two tectonostratigraphic zones, namely the Ordovician Elmtree Terrane and the adjacent Siluro-Devonian Cover (Fyffe and Fricker 1987). Figure 23 shows the simplified geology of the three 1:20 000 map areas that have been completed to date and Figure 24 shows schematic stratigraphic columns for Siluro-Devonian rocks in the area. In general, the mapping has shown that there are previously unrecognised Chaleurs Group sedimentary and volcanic rocks along the northwest side of the Elmtree block. Specific details are listed below under the headings Matapédia Cover and Elmtree Terrane.

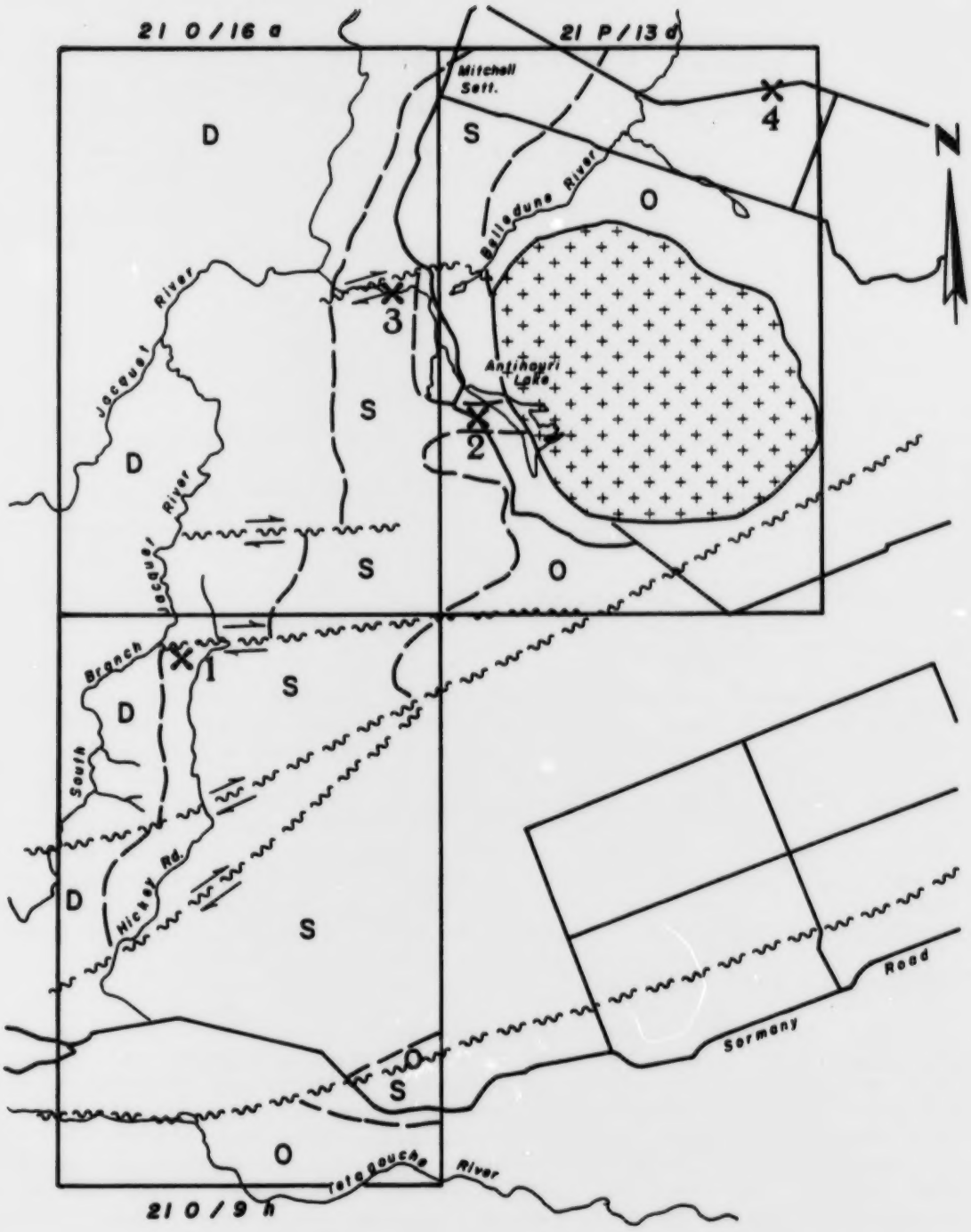


FIGURE 23. Simplified geology of 1:20 000 map areas; 21 O/9h, O/16a, and P/13d.

Antinouri Lake Granite

D — Devonian

S — Silurian

O — Ordovician

Fault showing relative movement

Geological contact

Location of stratigraphic section:

1. Taylor Brook section
2. Antinouri Lake Road section
3. Antinouri Lake Stream section
4. Highway 11 section

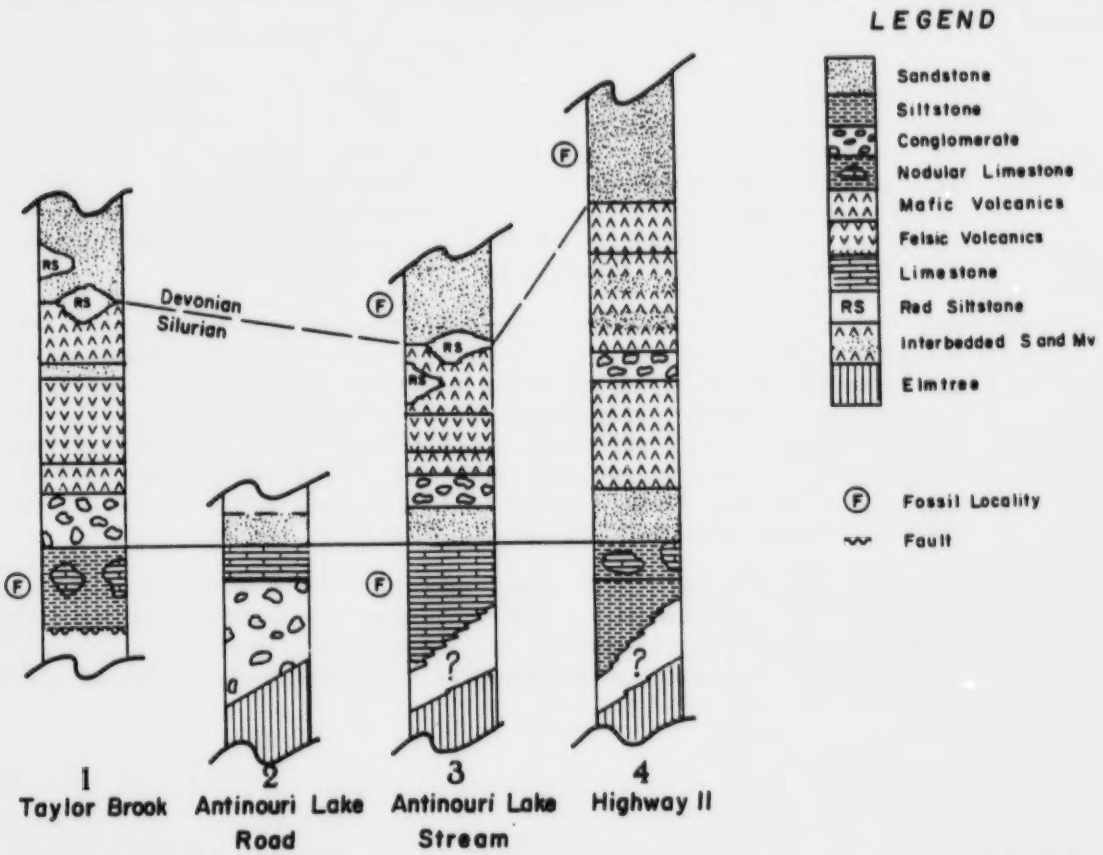


FIGURE 24. Schematic stratigraphic columns for Siluro-Devonian rocks in the Antinouri-Nicholas area. See Figure 23 for location of sections.

Matapédia Cover:

1) Limestone and/or nodular limestone in siltstone has been found at a number of localities (Figure 23) along the northwest side of the Elmtree block. Fossils were previously found at one of the localities (GSC # 91561) and gave an age of late Llandoverian to Ludlovian (middle Silurian). Fossils have been observed at two other localities, but have not yet been positively identified. This limestone is tentatively correlated with the Limestone Point and/or La Vieille formations along the coast, which range in age from late Llandoverian to Wenlockian (Noble 1976).

2) Pebble to cobble conglomerates overlie, underlie, and in places appear to be laterally equivalent to the limestone. These conglomerates contain abundant, commonly well rounded, mafic and felsic volcanic clasts and last year were considered younger than the Siluro-Devonian volcanic pile. However, these conglomerates are locally cut by mafic dykes and are overlain by Siluro-Devonian volcanic rocks, so the map (Plate 90-137) has been revised accordingly. The volcanic clasts in these conglomerates indicate that older Silurian volcanics were being eroded from a nearby source, probably a volcanic edifice.

3) In places, the limestone and conglomerate define east- to east-northeast-trending folds that appear to be overstepped by younger Silurian volcanic rocks, i.e., deformation and deposition were synchronous. The orientation of the fold axes suggests dextral offset along the north-south-trending Jacquet River fault, probably prior to movement along the northeast-trending Rocky Brook-Millstream Fault.

4) The first fossiliferous Devonian rocks overlie a band of amygdaloidal mafic lavas and minor intercalated redbeds, which can be traced across the map area by their magnetic signature. The boundary between the Silurian and Devonian rocks (Chaleurs and Dalhousie groups, respectively) is tentatively drawn at the top of this volcanic unit. Red beds and mafic lavas occur at the top of the type-Chaleurs Group in the Gaspé (Bourque 1975).

5) A number of east- to east-northeast-trending faults occur along the northwest side of the Elmtree block. To the north, the faults have an east-west strike, but to the south they are northeast-striking. All exhibit dextral offset.

6) Mineral occurrences are localized in three depositional sites: a) in amygdaloidal flow tops of Upper Silurian and/or Lower Devonian basalts; b) along the east- to east-northeast-trending faults; and c) in, and adjacent to, limestone that is within the contact aureole of the Antinouri Lake Granite.

Elmtree Terrane:

1) A tectonic mélange is widespread north of the Antinouri Lake Granite adjacent to the Fournier volcanics and also occurs south of the granite associated with a northeast-trending lens of mafic to ultramafic rocks, which is probably part of the Fournier Group. The mélange consists of sedimentary, and in places, mafic volcanic clasts (up to 2 m in size) enclosed in a matrix of black slate.

2) A northeast-trending, mafic-ultramafic volcanic unit south of the granite may have acted as a chemical or physical barrier to fluids emanating from the granite, because there are several mineral occurrences along its northern contact.

3) Thick beds of quartz wacke interbedded with phyllitic slate are found south of the probable Fournier volcanics and mélange described above, but to the north of these volcanics, quartz wacke is virtually absent and beds are typically contorted, broken, and dismembered (semi-mélange).

4) A belt of mafic volcanics, previously mapped as diabase dykes, has been recognised along the Belledune River to the north of the Antinouri Lake intrusion. These rocks are probably Ordovician.

5) A contact aureole extending 1 to 1.5 km outward from the Antinouri Lake Granite is marked by the development of grey- to mauve-coloured, generally pyritic, spotted hornfels. Limey layers within the aureole are locally altered to skarn (garnet-pyroxene tremolite) and calc-silicate hornfels (potassium feldspar, garnet, pyroxene, and actinolite). Amphibole veining is common near the granite and coarse white mica and beryl have been identified in zones and veins immediately adjacent to the granite.

6) A quartz-feldspar-porphyritic phase of the Antinouri Lake Granite, with a positive aeromagnetic signature, has been identified along the eastern side of the intrusion.

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ANTINOURI-NICHOLAS PROJECT, GEOSCIENCE DATA COMPILATION, GLOUCESTER AND RESTIGOUCHE COUNTIES, NEW BRUNSWICK (MDA)

Paul Rennick, Project Geologist

This project is a continuation of the geocompilation of data filed from mineral exploration assessment reports, which has been ongoing since 1984. The data compiled will serve to augment the Antinouri Lake mapping project and serve as input to the Geoscience Information System (GSIS).

The project area consists of parts of NTS map sheets 21 P/12, 21 P/13, and 21 O/16 in northeastern New Brunswick. Digital 1:50 000-scale base maps, obtained from Energy, Mines and Resources, Ottawa, are being used as the base for the geocompilation data.

The data from the assessment reports have been divided into a series of layers relating to the source and type of data. A dBASE database has been created for each of the layers, then converted to INGRES tables to enable utilization within the Geoscience Information System.

During the first year of the project, data will be compiled for 1:20 000-scale map sheets 21 O/16a, 21 P/13d, and 21 P/12d.

Ce projet fait suite à la compilation des données géoscientifiques tirées des rapports d'évaluation d'explorations minières, en cours depuis 1984. Les données compilées serviront à alimenter le projet de cartographie du lac Antinouri et seront ajoutées au Système d'information géoscientifique.

L'étude porte sur la région formée par des parties des cartes SNRC 21 P/12, 21 P/13 et 21 O/16 du nord-est du Nouveau-Brunswick. Des cartes de base numériques à échelle de 1 : 50 000, provenant d'Énergie, Mines et Ressources à Ottawa, servent de fond aux données géoscientifiques.

Les données provenant des rapports d'évaluation ont été divisées, par source et par type, en une série de couches. Chacune de ces couches a été entrée dans une base de données créée sur dBASE puis convertie en tables INGRES qu'on peut utiliser dans le Système d'information géoscientifique.

Pendant la première année du projet, les données seront compilé pour les cartes (échelle 1:20 000) 21 O/16a, 21 P/13d, et 21 P/12d.

INTRODUCTION

Compilation of mineral exploration assessment report data has been ongoing since 1984. The present project location is the Antinouri Lake area, south of Belledune in northern New Brunswick (Figure 22). The project area consists of parts of NTS map sheets 21 P/12, 13, and 21 O/16.

The data compiled in this project will be integrated into the geological mapping and mineral occurrence investigation, which are presently in progress.

The compiled graphic and textural data will also serve as input for the CARIS-based Geoscience Information System.

COMPILATION PROJECT PROCEDURES

The processes involved in data compilation are similar to previous project work, with the addition of digitizing the compiled data. This procedure may be divided into four phases each containing a series of steps. The phases consist of data collection, compilation, digital conversion and integration, with storage, distribution, and release being the end product.

PHASE I: DATA COLLECTION

The first phase of the project involves data collection from different sources. Firstly, base maps for the project were obtained in a digital format from Energy, Mines and Resources, Ottawa, at a 1:50 000 scale. Next, a database titled "Geoscan Index of Mineral Exploration Assessment Reports" was used as an index for mineral exploration surveys. This index contains a complete listing of exploration surveys completed in New Brunswick since 1953. This database is presently available in report form at Geological Surveys Branch offices in Bathurst, Fredericton, and Sussex. The third and final step in data collection is that of obtaining all available mineral exploration survey data. These data are contained in the assessment files, which are stored on microfiche, and on work-location maps stored on 1:50 000 NTS base maps.

PHASE II: DATA COMPILATION

During this phase, data collected is compiled graphically and texturally. First of all, the base maps are digitally customized using CARIS software, and plotted producing the desired hard-copy base maps at 1:20 000 scale. The graphical data from assessment reports are copied from microfiche to paper and converted to a common 1:20 000 scale. The data compiled from assessment surveys are divided by survey type as in past projects (Mersereau 1989), and manually plotted on the hard-copy base maps. The data are divided into four layers consisting of geological, geophysical, and goechemical surveys, with the fourth layer composed of conflicting, repetitive, or poorly located data from any of the survey types. Textural data from both assessment reports and the geoscan data tables are compiled in dBASE databases, revised from those initially created in a previous project by Three-D GeoConsultants. Databases were created for general assessment data, geological survey data, geophysical survey data, geochemical survey data, and diamond-drilling data.

PHASE III: DIGITAL CONVERSION AND INTEGRATION

The third phase of compiling data involves the conversion of the graphic and textural data to the CARIS-based geoscience information systems, and the integration of the two data types. The conversion of textural data involves converting the dBASE-type databases to ASCII format and importing them to

INGRES; the relational database management system that is compatible to the CARIS software package. The layers of compiled graphic geoscience data are manually digitized to CARIS-based thematic layers, which digitally overlie the existing digital base map.

The INGRES databases are topologically integrated with the CARIS thematic layers. The key to this integration is the Geoscan assessment report number, which is unique to each mineral exploration assessment report that has been filed in the province of New Brunswick since 1953.

PHASE IV: DATA STORAGE AND RELEASE

The final phase of the project involves the storage and release of the information compiled during the geocompilation project. The data will be stored in digital format, with release in both digital and hard copy form. The hard copies will be thematic and compilation maps with associated data tables. In digital forms the data will be available in standard formats.

ANTINOURI-NICHOLAS MINERAL OCCURRENCE STUDY, GLOUCESTER AND RESTIGOUCHE COUNTIES, NEW BRUNSWICK (PROV)

W.W. Gardiner, Mineral Deposits Geologist

A study of the mineral occurrences in the Antinouri-Nicholas project area was initiated concurrently with a bedrock mapping project in the same area. A total of one hundred and fifty mineral occurrences have been identified, with forty-two sites having been field-checked this year. Data collected on these mineral occurrences will be used to update the computerized mineral occurrence database and will be used to form the basis for a metallogenic study of the area as an aid to mineral exploration.

Une étude des indices minéralisés de la région d'Antinouri-Nicholas a été entreprise simultanément à un projet de cartographie du socle de cette région. Un total de cent cinquante indices minéralisés ont été identifiés, dont quarante-deux furent vérifiés sur le terrain cette année. Les données recueillies sur ces indices minéralisés seront utilisées pour mettre à jour la banque de données informatisées des indices minéralisés et seront utilisées comme base pour une étude métallogénique de la région devant servir à faciliter l'exploration minière.

INTRODUCTION

This project was initiated in conjunction with a bedrock mapping study of the Antinouri-Nicholas area (Walker et al., this volume).

To date, a total of one hundred and fifty mineral occurrences have been identified in the study area (Figure 22), sixty-two of which are presently included in the New Brunswick computerized mineral occurrence database. The remaining eighty-eight occurrences will be entered into the file when they have been more thoroughly studied. Forty-two of them were field-checked this summer to obtain more information with which to update the Province's computerized mineral occurrence database, which will eventually be merged into the Province's Geographic Information System (GIS). Samples from several mineral occurrences and their host rocks were collected to identify their genetic types and commodities present. Detailed mapping was undertaken at some locations. Representative samples will be analysed by multi-element techniques, and thin and/or polished sections of the mineralization prepared to determine the mineralogy of the occurrences. Although data acquisition is far from complete, the mineral occurrences have been tentatively classified as to type (Table 1). Field work related to each occurrence involves pin-pointing the location, sampling for multi-element analysis, slabbing and thin-sectioning, as well as describing the occurrence to fully understand its geological setting and geometry. Laboratory results will be useful in determining the mineralogy, mineral textures, and genesis of each occurrence.

VEIN GOLD OCCURRENCES

Vein gold occurrences in the area vary somewhat in appearance, but are generally typified by the Zarina occurrence. The gold is generally contained in narrow quartz veins with associated pyrite and, locally, with base metals. A number of these veins occur immediately north of the Rocky Brook-Millstream Fault and strike in a northwesterly direction.

MAFIC-DYKE-RELATED GOLD OCCURRENCES

This type of occurrence can be subdivided into; gabbro-related and diabase-related. The Elmtree West Gabbro Zone contains gold-bearing sulphides as disseminations and in veins within a wide carbonate-altered gabbro dyke. The diabase-related deposits, such as the Millstream West deposits, generally contain gold associated with fine needle-like arsenopyrite crystals in quartz-carbonate veins along the margins of the dykes and, less frequently, within the dykes. Some of the vein-gold occurrences may eventually be reclassified as this type.

MISCELLANEOUS GOLD OCCURRENCES

These two occurrences are of gold-bearing, fine-grained, needle-like arsenopyrite disseminated in Silurian grits and fine pebble conglomerates.

GRANITE-RELATED MO-CU-F OCCURRENCES

These occurrences fall into the broad classification of porphyry molybdenum deposits. They are hosted both by the granites and the sedimentary rocks within the contact metamorphic aureole. Most of the occurrences are associated with the Nicholas Dénys Granodiorite, although a few are found in the southwestern part of the Antinouri Lake Granite. The occurrences are comprised of disseminated and stringer sulphides with molybdenum predominating over copper. Fluorite occurs as a minor constituent of some of the occurrences.

VEIN/BRECCIA CU-BA OCCURRENCES

These occurrences are restricted to the eastern half of the Jacquet River graben, where they are generally contained within breccias of various types. The copper and barite may be present as disseminations or veinlets (stringers), or be contained in quartz veins within the breccias. The breccia types are currently being studied, but probably include flow-top breccias (mafic flows), hydrothermal breccias, volcanic breccias, and tectonic breccias. The bulk of the mineralization appears to be syn- to early post-volcanic in origin. These occurrences are of minor importance, but may be related to the larger deposits of Nash Creek or Patapat Brook.

VEIN PB-ZN-AG OCCURRENCES

This group of occurrences is subdivided into Silurian- and Ordovician-hosted deposits. The Ordovician occurrences are typified by the Keymet vein system, while the Silurian occurrences are represented by the Nigadoo veins.

SKARN BASE METALS AND/OR IRON

These stratabound deposits occur within limestones or calcareous argillites that have been contact metamorphosed to coarse-grained calc-silicate assemblages and porcellanites by the Antinouri Lake and Nicholas Dénys intrusives. The more significant occurrences are the Millstream deposit (Fe), the Beresford deposit (Cu), and the Madran deposit (Pb-Zn) hosted by Ordovician rocks, and the Patapat Brook deposit hosted by Silurian rocks.

OPHIOLITE-HOSTED COPPER OCCURRENCES

The ophiolite-hosted copper occurrences are best typified by the Turgeon deposit. Other occurrences are primarily copper disseminations within ophiolitic basalts.

MAFIC/ULTRAMAFIC NI-ZN-PB OCCURRENCES

These occurrences have been known for a number of years but their relationship to altered mafic/ultramafic dykes (sills?) has only recently been recognized. The mafic/ultramafic bodies are generally conformable to the host Ordovician metasediments and strike 60-80°. Mineralization appears to be confined to the margins of the dykes, which are highly bleached and altered.

MISCELLANEOUS OR UNCLASSIFIED OCCURRENCES

These occurrences are generally base-metal deposits on which insufficient data have been collected to enable classification at present.

TABLE 1

Deposit type	Number of occurrences
Vein Au	25
Mafic dyke Au	9
Miscellaneous Au	2
Granite-related Mo-Cu-F	13
Vein/breccia Cu-Ba	17
Vein Pb-Zn-Ag	10
Skarn-(Silurian-hosted)	7
-(Ordovician-hosted)	12
Ophiolite-hosted Cu, etc.	5
Mafic/ultramafic Ni-Pb-Zn	8
Manganese	3
Miscellaneous or unclassified	39
TOTAL	50

BRUNSWICK PROJECT, GLOUCESTER COUNTY, NEW BRUNSWICK (PROV)

J.P. Langton and S.R. McCutcheon

The aim of the Brunswick Project is to determine the stratigraphic and depositional setting of the major base-metal deposits of the Bathurst camp in northern New Brunswick.

Begun in 1988, the project to date has examined the rocks in the vicinity of the Brunswick No. 6 and 12 deposits. The rocks comprise, in ascending order, graphitic shale and quartzite, quartz-feldspar-augen schist (QFAS), quartz-augen schist (QAS), chlorite schist (CS), massive sulphide, mainly aphyric rhyolite (No. 6), and siltstone and volcanic derived sedimentary rocks (No. 12). The rocks above the two deposits are laterally equivalent. Many of the rocks in the study area, previously mapped as pyroclastic, are fragmental rhyolites that exhibit false pyroclastic textures. This has important implications for genetic models of the deposits. The area has been affected by at least four phases of deformation. A major thrust, associated with the first phase of deformation is present in the eastern part of the study area.

L'objectif du projet Brunswick est de déterminer l'environnement stratigraphique et dépositionnel des principaux gisements de métaux de base du camp Bathurst au nord du Nouveau-Brunswick.

Débuté en 1988, le projet a, à ce jour, examiné les roches aux environs des gisements Brunswick n^{os} 6 et 12. Les roches comprennent, en ordre ascendant, des shales graphitiques et des quartzites, des schistes oeillés à quartz-feldspath, des schistes oeillés à quartz, des schistes chloriteux, des sulfures massifs, principalement de la rhyolite aphanitique (n° 6), et des roches sédimentaires dérivées de siltstone et de roches volcaniques (n° 12). Les roches au-dessus des deux gisements sont latéralement semblables. Plusieurs des roches de la région sous étude, précédemment cartographiées comme pyroclastiques, sont des brèches rhyolitiques qui démontrent de fausses textures pyroclastiques. Ceci a une importance en rapport avec les modèles de genèse des gisements. La région a été le lieu d'au moins quatre phases de déformation. Une poussée majeure, associée à la première phase de déformation, est présente dans la partie orientale de la zone d'étude.

INTRODUCTION

Exploration for deeply buried base-metal deposits in the Bathurst Camp is hampered by the lack of detailed knowledge of the stratigraphy and structure of the felsic volcanic pile. Work undertaken with MDA 1 funding (1985-1989), specifically by Dr. C. van Staal and co-workers of the Geological Survey of Canada, has resulted in major revisions to both the stratigraphy and the structural history of a large part of the Bathurst Camp. The revisions were made possible by successfully integrating methods and results from many geological disciplines to produce a comprehensive model. These included: 1) detailed structural mapping (1:12 500 scale), 2) lithogeochemical analyses, 3) geo-

physical surveys and 4) radiometric age dating. The bulk of this recent work was concentrated on the rocks overlying the felsic volcanic pile, which dominates the southern and western parts of the camp. Therefore, the principal objective of the provincially funded Brunswick Project is to produce, as an extension to the GSC's work, thematic (1:10 000 scale) maps of the felsic volcanic pile, and to establish a detailed stratigraphy of the same. This, in turn, will facilitate the determination of the depositional and stratigraphic settings of the major base-metal deposits within the Bathurst Camp, and allow new deposits to be targeted on the basis of predictive geology. Other objectives include: 1) to determine which parts of the area, mapped as "felsic volcanics", are of sedimentary origin; 2) to determine which rock units are laterally (stratigraphically) equivalent; and 3) to delineate areas or horizons that are favourable for base-metal exploration.

PREVIOUS WORK

Previous work on the project involved a pilot lithogeochemical sampling program, which examined the chemistry of the chlorite schist (CS), quartz augen schist (QAS), and the quartz-feldspar porphyry (QFP), that successively underlie the Brunswick No. 6 and No. 12 deposits (Figure 25). Results of chemical analyses (McCutcheon et al. 1989) indicate that; 1) the QFP (originally quartz-feldspar augen schist or QFAS) is a lava flow and/or a high-level porphyry within the QAS, not a pyroclastic unit as was previously thought; 2) the QAS is of sedimentary origin and contains quartz and, rarely, feldspar grains from 1-4 mm in diameter. The grains were derived from subaerially exposed quartz-feldspar porphyries or granites; 3) the CS is a greenish grey siltstone, not the product of hydrothermal alteration of volcanic rock.

Drill core from the rocks lying above the ore horizon at No. 6 and 12 were examined last year. Results suggest that: 1) the felsic-looking rocks above the No. 12 deposit are actually acid hyaloclastites (in part reworked), interlayered with fine grained sedimentary rocks; 2) the rocks above the No. 6 deposit probably represent a rhyolite dome and comprise mainly aphyric flows and porphyritic flows and/or shallow intrusions (McCutcheon et al. 1989, van Staal 1984, 1987). The variation in rock type above the two deposits reflects a lateral facies change from felsic volcanic rocks to sedimentary rocks. A similar facies change is exposed in the Tetagouche River below Tetagouche Falls.

A model that incorporates the rock types and features present around the Brunswick deposits is shown in Figure 26. The greenish grey siltstone (GGS), which immediately underlies the sulphide deposits, acted as an impermeable cap rock. The QAS was the aquifer/reservoir for sulphide-rich fluids that were generated by dewatering of the underlying graphitic shales

of the Miramichi Group. Emplacement of QFP magmas heated the sedimentary pile. Syndepositional faulting (earthquakes) breached the QAS reservoir resulting in catastrophic release of large volumes of metal-saturated, relatively low temperature fluid, onto the sea floor. A corollary of this model is that most of the hydrothermal alteration effects related to sulphide deposition are semiconformable and within the QAS unit rather than associated with a cross-cutting stringer zone.

CURRENT WORK

This year, detailed (1:10 000) structural and geological mapping of the area to the south and southwest of the No. 6 deposit was initiated, and is on-going (NTS map sheets; 21-P/5,101; 102; 201; 202), (Figure 25).

Geology:

Preliminary results indicate that the division of the felsic volcanic rocks into two major formations, the Nepisiguit Falls and Flat Landing Brook formations (van Staal and Fyffe 1990), is valid. The formations respectively comprise: 1) quartz (+/- feldspar) wackes (QAS) and associated quartz-feldspar phyric rhyolite flows or shallow intrusions (QFP) with minor greenish grey siltstone (GGS) and; 2) aphyric and feldspar phyric rhyolitic rocks (rhyolite domes), with associated peripheral, fragmental and epiclastic rocks. Field relationships indicate that much of the Nepisiguit Falls Formation, previously interpreted as QFP is actually QAS, i.e., of sedimentary origin. Furthermore, most of the so-called tuffaceous/pyroclastic rocks included in the Flat Landing Brook Formation are rhyolites, that have undergone devitrification and fragmentation, and in some cases reworking. The resulting fragmental rock contains 1-5 mm sized fragments that may be misidentified as phenocrysts, crystals, or lapilli. These hyaloclastitic rocks grade into blocky "carapace" breccias and thence into massive rhyolite. Other false pyroclastic textures include nodular devitrification features, that impart a pumice-rich pseudobreccia appearance (Allen 1988). In some areas the fragmental rocks can be traced into bedded epiclastic units that are interpreted as the flanks of rhyolite domes. Lithogeochemical and petrological data on this suite of rocks are forthcoming.

The abundance of fragmental rocks, and the reinterpretation of many pyroclastic units as sedimentary rocks, discredits the collapsed caldera model proposed by Harley (1979), as a genetic model for the camp.

Structure:

Rocks within the study area show at least four sets of structures, that have been designated D_1 to D_4 on the basis of overprinting relationships. The S_1 cleavage may be a poorly to well developed fabric and is occasionally mylonitic. No F_1 folds were outlined in the study area, but their

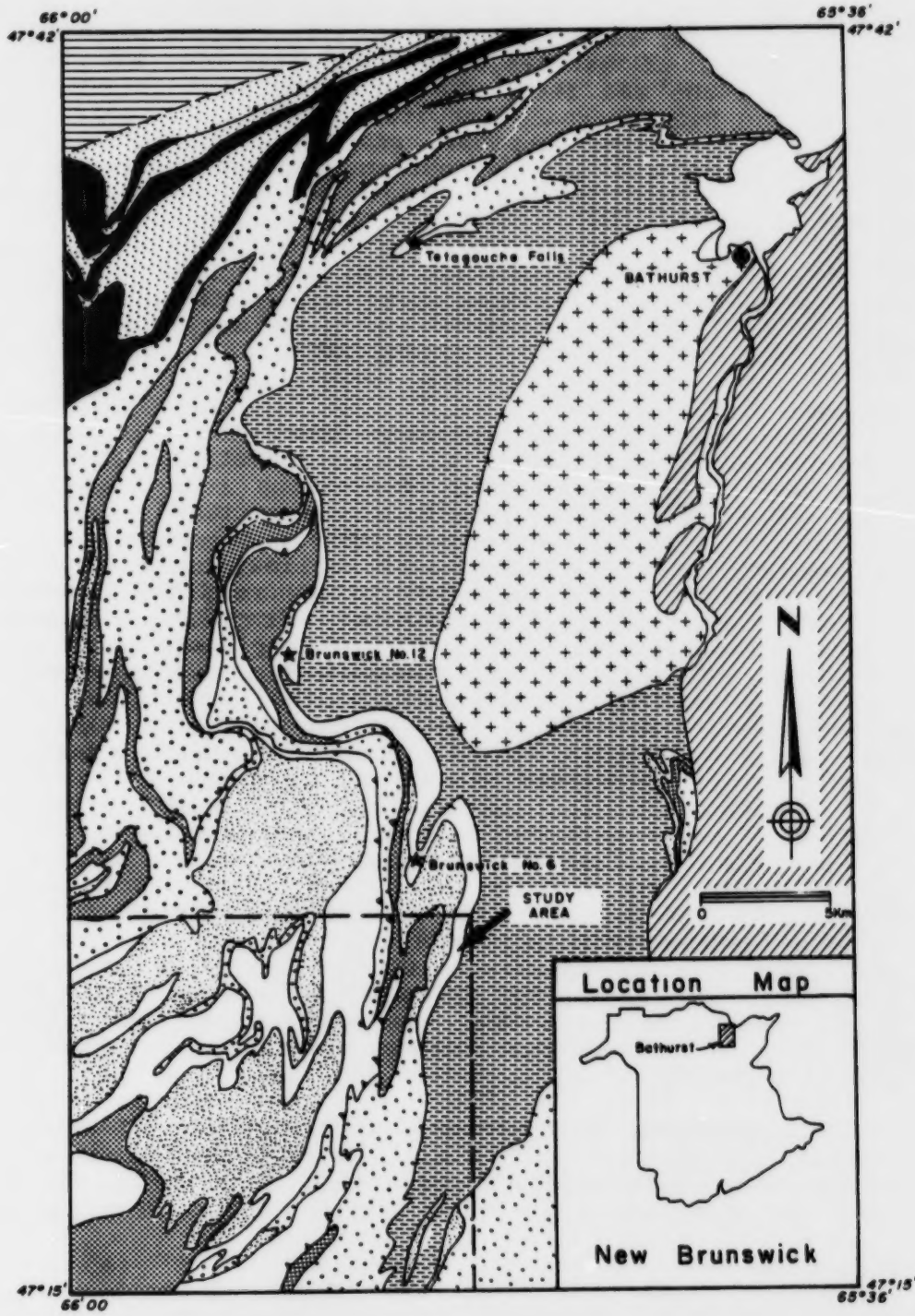

FIGURE 25. Geological map of the area around the Brunswick No. 6 and 12 deposits.

LEGEND

Carboniferous cover

DEVONIAN

Pabineau granite

SILURIAN

Chaleurs Group

ORDOVICIAN

FOURNIER GROUP

Mainly thick bedded dark grey shales and lithic/feldspathic wacke

Tholeiitic basalt

TETAGOUCHE GROUP

Mainly thin bedded, dark grey phyllitic shale and siltstone

Alkaline and tholeiitic basalt

Rhyolite (Flat Landing Brook Fm.)

Quartz-feldspar porphyry (Nepisiguit Falls Fm.)

MIRAMICHI GROUP

Mainly interbedded graphitic phyllite and quartz wacke and quartzite.

SYMBOLS

geological contact

fault

thrust fault

thrust fault; inferred

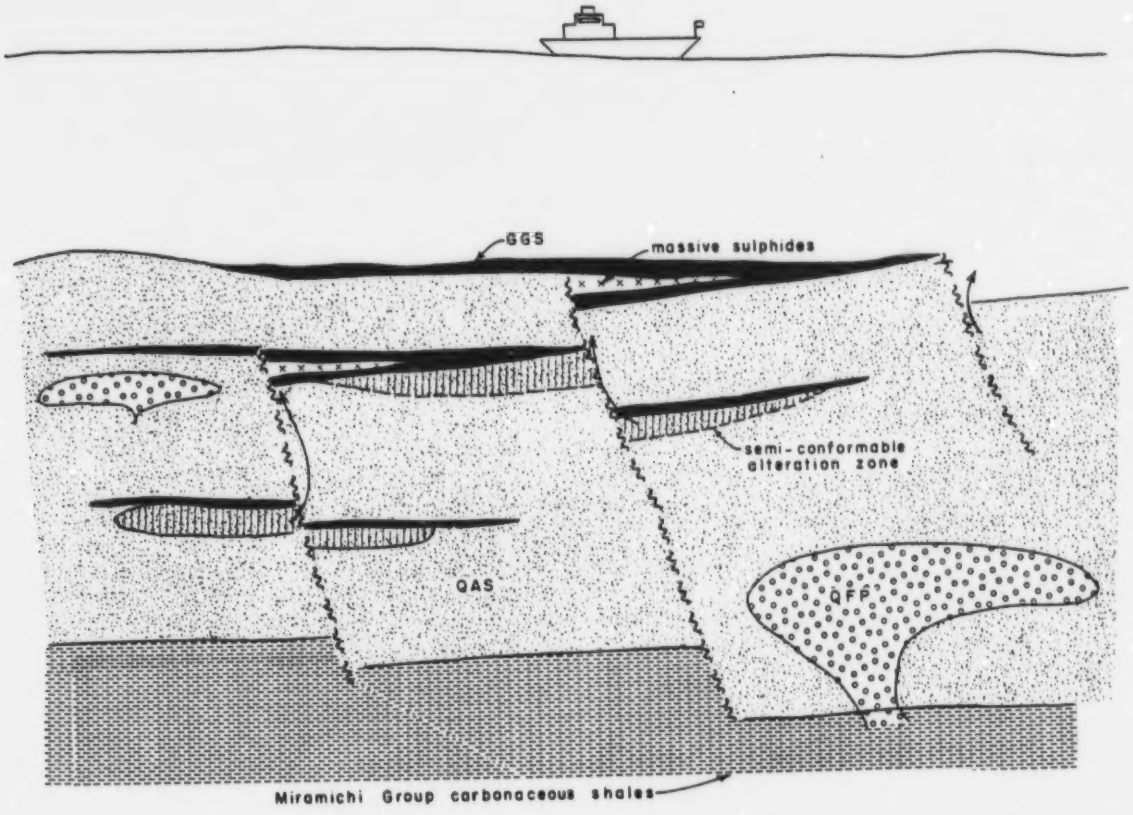

FIGURE 26. Schematic diagram showing features of a possible genetic model for the Brunswick deposits.

existence has been proven in other parts of the camp. The D_1 event is associated with thrusting (van Staal 1987). A mylonitic zone along the easternmost occurrence of felsic volcanic rocks is interpreted as a major thrust fault, that apparently cuts down-section and juxtaposes QFP against phyllitic sedimentary rocks and mafic volcanic rocks of the Tetagouche Group (Figure 25). A prominent, near-vertical stretching lineation (L_1) is strongly developed throughout the area.

The geometrical distribution of the rock units reflects moderately plunging, tight F_2 folds refolded by steeply plunging, open F_3 folds (Figure 27). Along the limbs of the F_2 folds the S_1 cleavage is often transposed into parallelism with S_2, yielding a composite $S_{1,2}$, or S-main, cleavage. In general, the S_2 fabric strikes north-south, and the S_3 fabric strikes northeast-southwest. However, in the western part of the area the "main" foliation swings into an east-west orientation and the S_3 foliation also shows a clockwise rotation, indicating the influence of a later (F_4) fold.

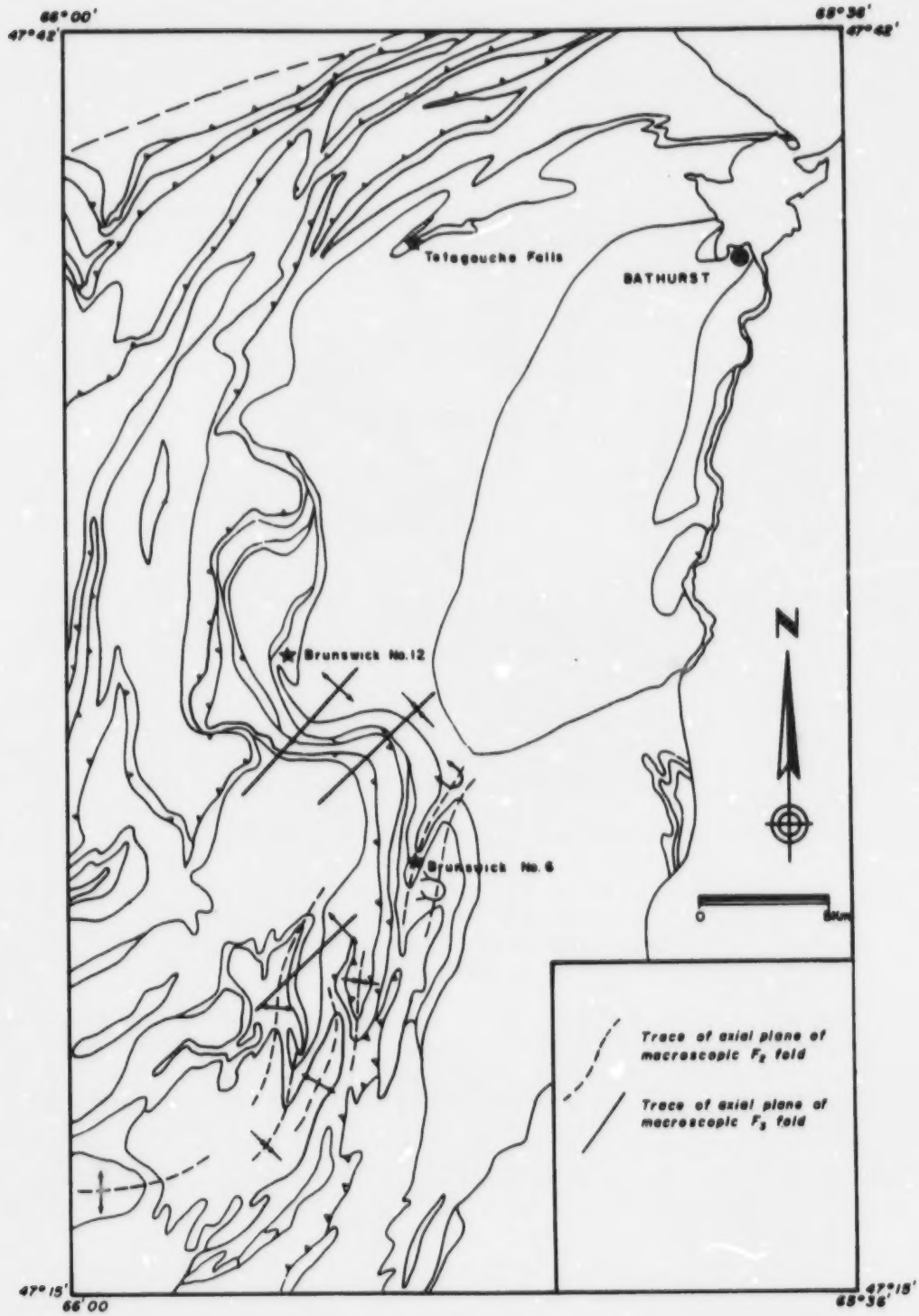

FIGURE 27. Axial traces of major F_2 and F_3 folds in the vicinity of the study area. See Figure 25 for geology and symbols.

SUMMARY

1) A semi-conformable alteration zone, characterized by abundant pyrite and pervasive sericitic alteration, is present in the QAS in the central part of map area 21 P/5-202.

2) False pyroclastic textures are common and indicate that many of the rocks previously mapped as pyroclastics and tuffs are fragmental rhyolites.

3) A major thrust fault is present in the eastern part of the area, which carried the Nepisiguit Falls Formation over a lateral facies change within the Tetagouche Group.

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NOTES

GEOLOGICAL SURVEYS BRANCH

SUSSEX REGIONAL OFFICE

ACTIVITIES OF THE SUSSEX REGIONAL OFFICE

A.A. Ruitenberg, Regional Geologist

The Sussex Regional office is staffed by Arie Ruitenberg (Regional Geologist), Malcolm McLeod (Assistant Regional Geologist), Maurice Mazerolle (Engineering Technician and Claims Inspector), and Freda Kelly (Administration Services Officer). Alain Caron, Susan Johnson, and David Rose were employed under the Canada-New Brunswick Mineral Development Agreement. Angela Roy, Donald Hebb, Kenneth Jones, and Matthew Munn were hired as field staff for the summer and fall seasons.

PROGRAMS AND PROJECTS

M.J. McLeod, S.C. Johnson, and A.A. Ruitenberg compiled the regional geology and field-checked problem areas in parts of 21G, H, and I, which are to be included in a regional 1:250 000-scale compilation of southern New Brunswick. The main emphasis in the field work was on regional correlation in the St. Croix Terrane and Mascarene Cover Sequence in the southwestern part of the Province and definition of major fault systems that controlled the emplacement of epigenetic gold deposits. Some of the major fault zones that define terrane bcundaries were traced under the Carboniferous and younger sedimentary cover by mapping erosional windows containing older Paleozoic rocks.

A. Caron and A.D. Roy continued a detailed investigation of the Lake George Antimony-Gold Deposit. The most representative underground workings were mapped by S.E. Watters and A.D. Roy prior to flooding of the mine in January, 1990. During the summer, more than 200 drill cores were examined and sampled. Emphasis of the investigation was on different types of vein systems and associated rock alteration, structural relationships of the veins and host rocks, and delineation of the regional structure in the mine area. Bedding attitudes within and outside the underground workings were determined from cores that were drilled in close proximity to each other, but with significantly different orientations.

D.G. Rose and D. Hebb located and described most of the major mineral occurrences in the area covered by 1:250 000 map sheet 21G. Samples were cut with a diamond saw and representative mineralized material was sent for assay. Sample suites of most occurrences were stored at the Sussex office. The results of this investigation will be used to update the computerized mineral occurrence file.

M.J. McLeod made the final corrections on a report describing the geology, geochemistry, and mineral deposits of the Saint George Batholith. The report will be accompanied by two 1:50 000 geological maps. Detailed 1:20 000 geological maps of the batholith were published in 1987.

D.G. Rose and S.C. Johnson finalized a report describing the New Brunswick Computerized Mineral Occurrence Database, which was published as Mineral Resource Report 3. A.A. Ruitenberg, S.C. Johnson, and L.R. Fyffe made the final revisions to a paper on epigenetic gold deposits and their tectonic setting in the New Brunswick Appalachians, which was published in the Canadian Mining and Metallurgical Bulletin. A.A. Ruitenberg and L.R. Fyffe finalized a report describing granite-related mineral deposits in New Brunswick, which will be published as a geoscience report.

A.A. Ruitenberg and M.J. McLeod commenced a comparative investigation of massive sulphide deposits in the Avalon and adjacent St. Croix terranes in southern New Brunswick, Cape Breton, and eastern Maine. The stratigraphic setting of the Mindamar Deposit in Cape Breton was found to be similar to that of the Teahan Deposit in southern New Brunswick. The Pembroke Deposit in eastern Maine occurs in a geological setting similar to that of the more prominent base-metal sulphide occurrences in the Mascarene Peninsula area. More investigation is required to find equivalents in New Brunswick of the Blue Hill SEDEX Deposit and the typical Kuroko-type Harbourside Deposit, which occur in southern Maine. However, the Ordovician strata in New Brunswick appear to have potential for SEDEX deposits similar to the Blue Hill Deposit.

M.J. McLeod presented a paper on mineral deposits associated with the Saint George Batholith, southwestern New Brunswick at the Annual Meeting of the Geological Association of Canada in Vancouver, B.C. A.A. Ruitenberg presented a paper on the relationship of gold deposits to tectonic evolution of the New Brunswick Appalachians at the Gold Tech 4 conference in Reno, Nevada. He also attended a field trip to the major gold deposits in the Carlin Trend and the Independence Range of Nevada.

The regional geologist continued participation in a committee mandated with evaluation of Mineral Exploration Stimulation Program (MESP) proposals. This program has resulted in the discovery of several economically significant gold occurrences in southern New Brunswick in recent years. He continued to provide geological advice to the technical committee charged with providing guidance to the forest-site classification group of the Department of Natural Resources and Energy. Paucity of regolith maps in the Province continued to severely limit this activity. The regional geologist continued to serve on the resource sub-committee of the Saint Croix International Waterway Authority, which was established by the State of Maine and the Province of New Brunswick.

The geological staff provided consulting services from the regional office and in the field to numerous company geologists and prospectors. Demand for geologic advice on activities related to groundwater exploration and regional waste disposal sites has increased.

F.H. Kelly and J.M. Mazerolle continued to provide their efficient support services to the mineral industry and geological staff.

J.M. Mazerolle completed drafting maps and diagrams for the MDA-supported investigation of the Saint George Batholith and the Cape Spencer area. Slides were prepared for the oral presentation at the annual meeting of the Geological Association of Canada and the Gold Tech 4 Conference. Figures and maps were drafted for a paper on gold deposits in New Brunswick for publication in the Canadian Mining and Metallurgical Bulletin and the Review of Activities. During the summer, a major re-organization of the drill-core facility was undertaken with the assistance of a casual employee. Claim inspections were carried out when required. A project involving the computerization and compilation of all geochemical data in southern New Brunswick was started. The project initially concentrated on map sheet 21 G/14E in order to complement the MDA-supported investigation of the Lake George Mine area.

ACTIVITÉS DU BUREAU RÉGIONAL DE SUSSEX

A.A. Ruitenberg, géologue régional

Le personnel du bureau régional de Sussex se compose de Arie Ruitenberg (géologue régional), Malcolm McLeod (géologue régional adjoint), Maurice Mazerolle (technicien supérieur et inspecteur de claims) et Freda Kelly (adjointe aux services administratifs). Alain Caron, Susan Johnson et David Rose furent employés aux termes de l'entente Canada-Nouveau-Brunswick l'exploitation minérale. Angela Roy, Donald Hebb, Kenneth Jones, et Matthew Munn furent recrutés comme personnel sur le terrain pour les saisons d'été et d'automne.

PROGRAMMES ET PROJETS

En rapport avec la compilation régionale à l'échelle 1:250 000 pour le sud du Nouveau-Brunswick, M.J. McLeod, S.C. Johnson, et A.A. Ruitenberg ont effectué la compilation de la géologie régionale et vérifié sur le terrain les zones problématiques de certaines portions des cartes 21 G, H et I. Les travaux sur le terrain ont surtout mis l'accent sur la corrélation régionale dans la formation de St. Croix et la séquence sédimentaire de Mescarene situées dans la partie sud-ouest de la province, ainsi que sur la définition des principaux systèmes de failles qui contrôlent le développement des gisements aurifères épigénétiques. Certaines des zones de failles majeures qui délimitent les formations ont été suivies sous la couverture sédimentaire récente et le carbonifère, à l'aide de la cartographie des fenêtres d'érosion renfermant des roches paléozoïques plus anciennes.

A. Caron et A.D. Roy ont poursuivi l'examen détaillé du gisement d'or-antimoine du lac George. Les puits d'extraction les plus représentatifs furent cartographiés par S.E. Watters et A.D. Roy avant l'inondation de la mine en janvier 1990. Durant l'été, plus de 200 carottes de forage furent examinées et échantillonnées. L'investigation a mis l'accent sur les différents types de systèmes de veines et l'altération correspondante, et sur l'identification de la structure régionale dans la région de la mine. La position des strates à l'intérieur et à l'extérieur des puits d'extraction fut déterminée à partir de carottages effectués tout près les uns des autres mais d'orientations différentes.

D.G. Rose et D. Hebb ont localisé et décrit la majorité des principaux indices minéralisés de la région couverte par la carte au 1:250 000 21G. Les échantillons furent coupés à l'aide d'une scie à diamants et des échantillons minéralisés représentatifs furent envoyés pour essais. Des séries d'échantillons pour la majorité des indices ont été entreposées au bureau de Sussex. Les résultats de ces travaux seront utilisés pour mettre à jour le dossier informatisé des indices minéralisés.

M.J. McLeod a effectué les dernières corrections au rapport décrivant la géologie, la géochimie et les gisements du batholite de Saint George. Le rapport sera accompagné de deux cartes géologiques au 1:50 000. Des cartes du batholite au 1:20 000 furent publiées en 1987.

D.G. Rose et S.C. Johnson ont finalisé le rapport décrivant la banque de données informatisée des gîtes minéraux du Nouveau-Brunswick, qui fut publié comme rapport n° 3 sur les ressources minérales. A.A. Ruitenberg, S.C. Johnson et L.R. Fyffe ont effectué les dernières révisions à un article sur les gisements aurifères épigénétiques et leur mise en place structurale dans les Appalaches du Nouveau-Brunswick. Cet article fut publié dans le bulletin de l'ICM. A.A. Ruitenberg et L.R. Fyffe ont terminé un rapport décrivant les gisements minéraux reliés à des granites au Nouveau-Brunswick qui sera publié comme rapport géoscientifique.

A.A. Ruitenberg et M.J. McLeod ont entrepris une étude comparative des gisements de sulfures massifs des formations d'Avalon et de St.Croix, au sud du Nouveau-Brunswick, au Cap Breton et dans l'est du Maine. Le mode de mise en place stratigraphique du gisement de Mindamar au Cap Breton s'avère être semblable à celui du gisement de Teahan dans le sud du Nouveau-Brunswick. Le gisement de Pembroke dans l'est du Nouveau-Brunswick se trouve dans un environnement géologique semblable aux principaux gîtes de sulfures de métaux de base situés dans la région de la péninsule de Mascarene. D'autres recherches sont nécessaires afin de trouver, au Nouveau-Brunswick, des gisements équivalant à ceux de Blue Hill (SEDEX) et de Harbourside (type Kuroko) au sud du Maine. Cependant, les couches ordoviciennes du Nouveau-Brunswick semblent avoir

le potentiel pour des gisements SEDEX semblables à celui de Blue Hill.

M.J. McLeod a présenté un article sur les gisements minéraux associés au batholite de Saint George, au sud-ouest du Nouveau-Brunswick, à la rencontre annuelle de l'Association géologique du Canada tenue à Vancouver. A.A. Ruitenberg présenta un article sur le lien entre les gisements aurifères et l'évolution tectonique des Appalaches du Nouveau-Brunswick à la conférence Gold Tech 4 à Reno au Nevada. Il a aussi participé à une excursion sur le terrain aux principaux gisements d'or du Carlin Trend et de l'Independance Range au Nevada.

Le géologue régional a poursuivi sa participation au comité mandaté d'évaluer les propositions faites au programme de stimulation de l'exploration minière (PSEM). Ce programme a permis la découverte, au cours des dernières années, de plusieurs gîtes aurifères dans la partie sud du Nouveau-Brunswick. Il a continué d'offrir des conseils se rattachant à la géologie au comité qui doit aviser le groupe de classification des sites forestiers du ministère des Ressources naturelles et de l'Énergie. Le manque de cartes régolithiques dans la province a continué à grandement limiter cette activité. Le géologue régional a continué à être membre du sous-comité des ressources de la Commission du bassin international de la rivière St. Croix, qui fut établi par l'état du Maine et la province du Nouveau-Brunswick.

Le personnel en géologie a fourni des services de consultation, à partir du bureau et sur le terrain, à plusieurs géologues d'entreprises privées et à des prospecteurs. La demande pour de l'information géologique se rattachant à la recherche d'eau souterraine et aux sites d'enfouissement régionaux a augmenté.

S.H. Kelly et J.M. Mazerolle ont continué à fournir leur soutien efficace tant à l'industrie minière qu'au personnel en géologie.

J.M. Mazerolle a achevé le dessin des cartes et des diagrammes pour l'investigation du batholite de Saint George dans la région du cap Spencer, un projet soutenu par l'EDM. Des diapositives furent préparées pour la rencontre annuelle de l'Association géologique du Canada et la conférence Gold Tech 4. Les figures et les plans furent dessinés pour un article sur les gisements aurifères du Nouveau-Brunswick devant être publié dans le bulletin de l'ICM et la Revue d'activités. Pendant l'été, une réorganisation majeure de l'entrepôt de carottes de forage a été entreprise avec l'assistance d'employés temporaires. Des inspections de claims furent effectuées selon le besoin. Un projet impliquant la compilation et l'informatisation de toutes les données géochimiques du sud du Nouveau-Brunswick a été entrepris. Le projet s'est d'abord concentré sur la feuille de la carte 21 G/14e de façon à compléter l'investigation de la zone de la mine du lac George, un projet soutenu par l'EDM.

COMPILATION AND CORRELATION OF SOUTHWESTERN NEW BRUNSWICK GEOLOGY (CHARLOTTE, QUEENS, KINGS, AND SUNBURY COUNTIES), NEW BRUNSWICK (PROV & MDA)

M.J. McLeod, S.C. Johnson, and A.A. Ruitenberg

Work on the 1:250 000 compilation and correlation project for southwestern New Brunswick included a preliminary compilation of 21 G and field investigations emphasizing pre-Carboniferous Paleozoic rocks in 21 H and parts of 21 G and 21 I. Previously established and newly defined map units in the Avalon Terrane, Mascarene Cover Sequence, and St. Croix Terrane were extended to the southwest and northeast of the Annidale area.

The extension of gold- and base-metal-bearing rocks of the St. Croix Terrane to the northeast beneath a thin cover of Carboniferous rocks indicates that further exploration in this area is warranted.

Les travaux sur le projet de compilation et de corrélation au 1:250 000 couvrant le sud-ouest du Nouveau-Brunswick ont inclus une compilation préliminaire de la carte 21 G, et des investigations sur le terain mettant l'accent sur les roches paléozoiques du pré-carbonifère couvrant la carte 21 H et certaines parties des cartes 21 G et 21 I. Des unités de cartographie précédemment établies et nouvellement définies dans les formations d'Avalon et de St. Croix, et dans la séquence sédimentaire de Mascarene, furent prolongés vers le sud-ouest et le nord-est de la région d'Annidale.

Le prolongement des unités rocheuses minéralisées en or et en métaux de base de la formation de St. Croix vers le nord-est, sous une mince couche de roches carbonifères, indiquent que de plus amples travaux sont justifiés dans cette région.

During the past year, work on the 1:250 000 compilation and correlation project for southwestern New Brunswick included preliminary compilation of 21 G at a scale of 1:50 000 and field investigations with emphasis on pre-Carboniferous Paleozoic rocks in 21 H and parts of 21 G. Field checking and correlation of major map units (M. McLeod and A. Ruitenberg) was conducted throughout the area studied and more detailed mapping was carried out particularly in problematical areas (S. Johnson). Due to the magnitude of the project, the maps and reports produced by numerous previous workers were extensively utilized and are gratefully acknowledged.

The project area encompasses three main packages of rocks that include Cambrian rocks of the Avalon Terrane, Siluro-Devonian rocks of the Mascarene Cover Sequence (deposited on the Avalon Terrane) and Ordovician rocks of the St. Croix Terrane (basement unknown) (see discussion by Fyffe 1989; Ruitenberg et al. 1990) (Figures 28 and 29). These main packages of rocks were traced to the northeast by mapping scattered inliers that occur within the Carboniferous Platform. The northernmost inlier contains Silurian rocks of the Fredericton Cover

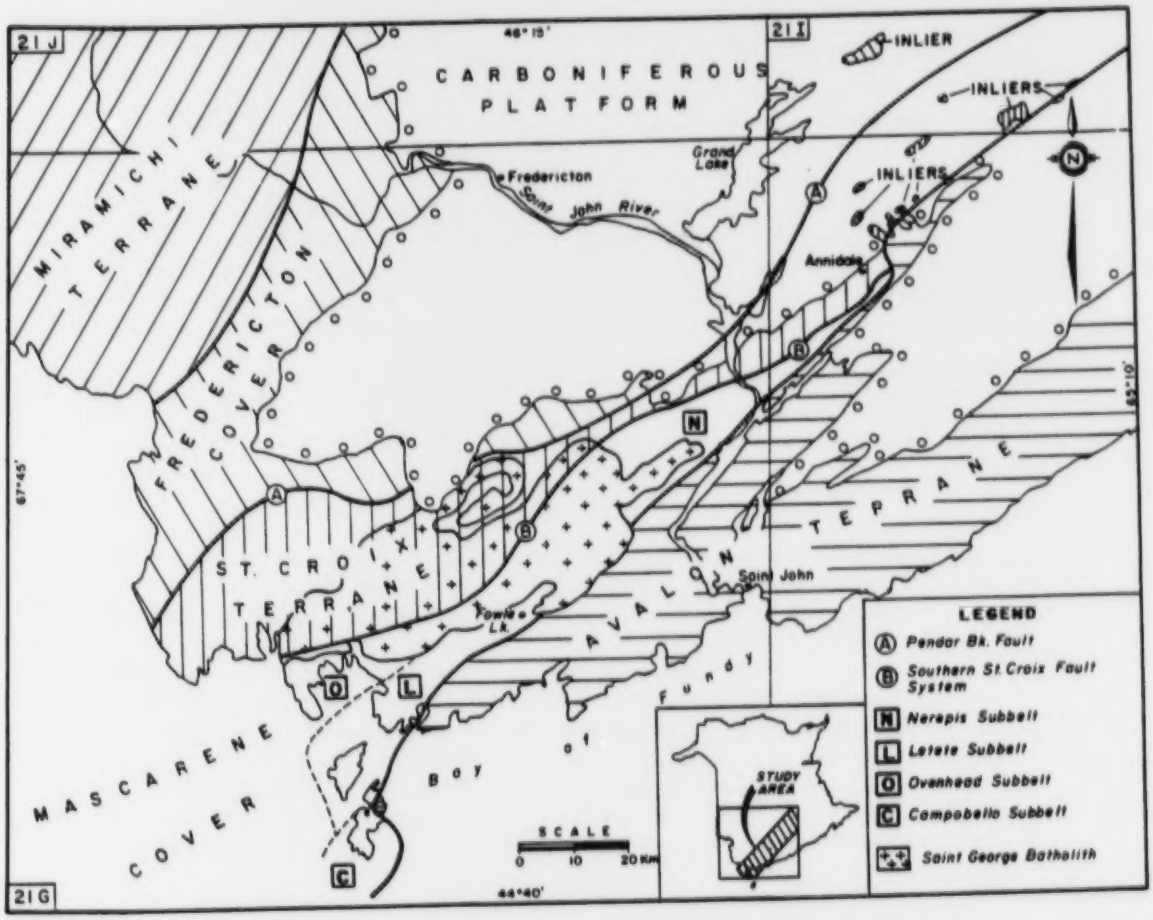

FIGURE 28. Tectonostratigraphic subdivisions of southwestern New Brunswick. Note: the Mascarene Cover is divided into the Nerepis, Letete, Ovenhead, and Campobello subbelts.

Sequence, which represents another major package of rocks in southwestern New Brunswick (e.g., Fyffe 1989).

The detailed geology to the northeast of the Saint George Batholith is shown in Figure 30. A relatively undeformed sequence of sedimentary and volcanic rocks within a fault block along the southeastern margin of this area is considered part of the Avalon Terrane. West of longitude 66°00′, the upper (Unit ϵ_{SJ}) and lower (Unit ϵ_{SV}) parts of the succession (McCutcheon and Ruitenberg 1987) contain fossiliferous grey to black and nonfossiliferous red sedimentary rocks interbedded with mostly mafic volcanic rocks (McCutcheon 1981). East of longitude 66°00′, mafic and felsic volcanic rocks predominate (Unit ϵ_{VS}) and are associated with a variety of sedimentary rocks similar to those along strike to the southwest. Contacts of these units with other older and younger units in the project area are faulted but the entire sequence is a probable correlative of the lower Saint John Group as suggested by McCutcheon (1981).

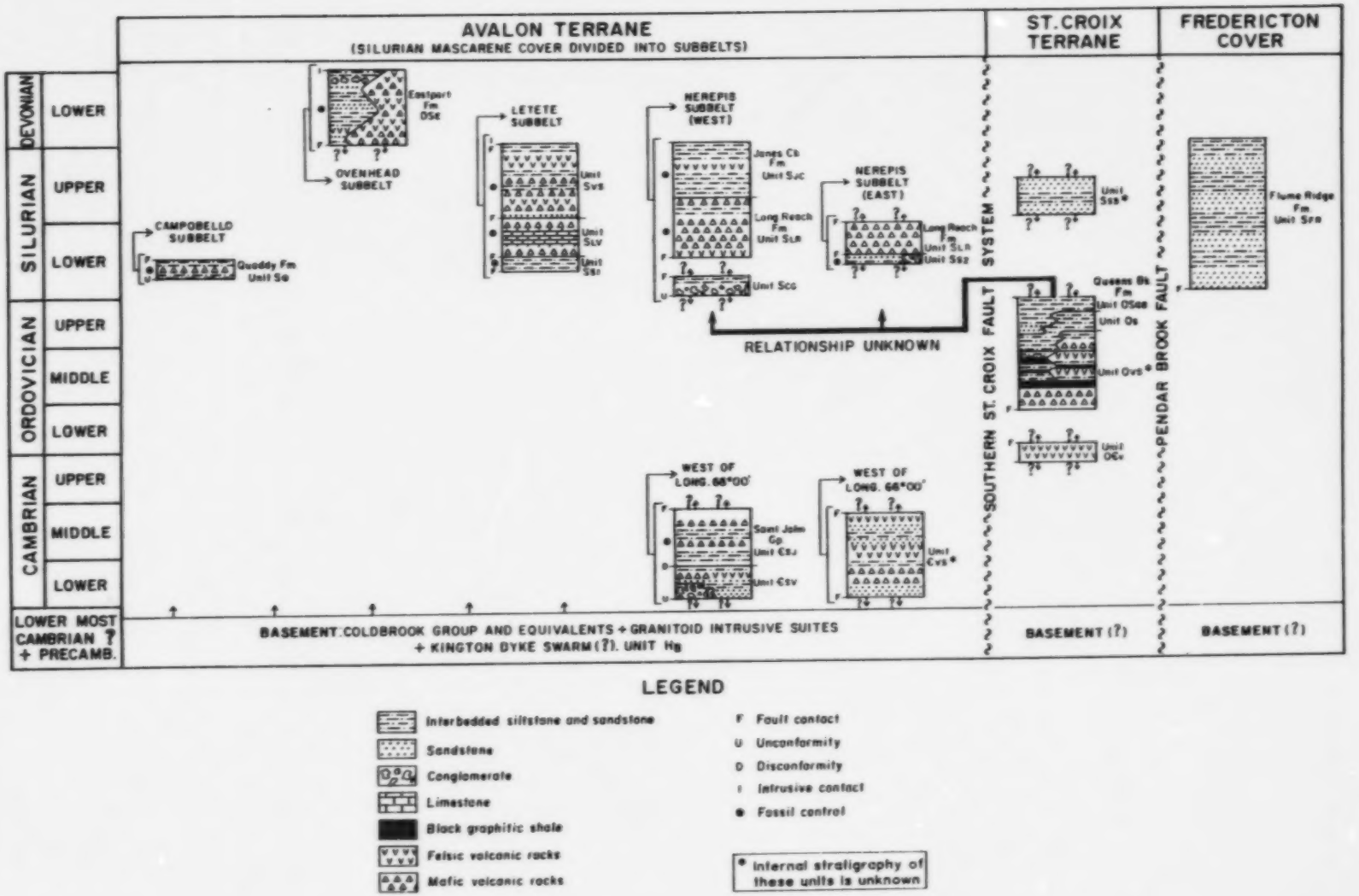

FIGURE 29. Schematic stratigraphic columns for the Avalon Terrane (and its Mascarene Cover), St. Croix Terrane, and Fredericton Cover Sequence.

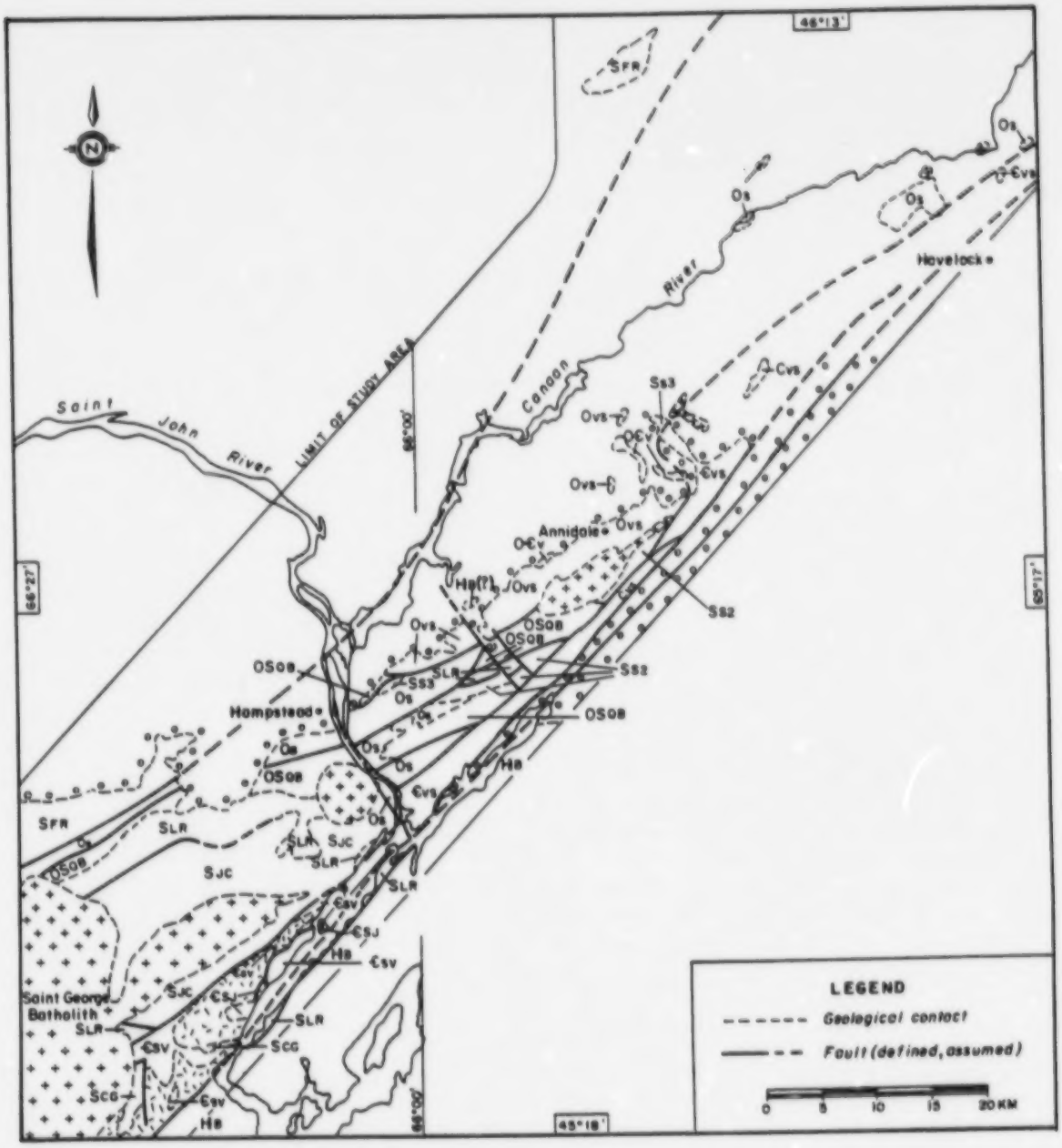

FIGURE 30. Geology of southwestern New Brunswick (northeastern portion).

The St. Croix Terrane, bounded to the north by the Pendar Brook Fault, is characterized by intensely sheared and faulted sedimentary (Unit O_S) and volcanic (Unit O_{VS}) rocks (Figure 30). Unit O_S contains fine-grained sedimentary rocks that range in colour from grey and black to dark green and purple; volcanic debris in the coarsest grained rocks and graphitic

LEGEND

CARBONIFEROUS

Sedimentary rocks (Horton Gp., Windsor Gp., Hopewell Gp., Petitcodiac Fm., Piskahegan Gp.)

DEVONIAN AND SILURIAN

Granitoid rocks (Saint George Batholith, Evandale Granite, Stewarton Complex)

SILURIAN

S_{JC} Sedimentary and felsic volcanic rocks (Jones Creek Fm.)

S_{LR} Mafic volcanic rocks, and minor sedimentary and felsic volcanic rocks (Long Reach Fm.)

S_{CG} Sedimentary rocks (mainly conglomerate)

S_{S2} + S_{S3} Sedimentary rocks (quartzose sandstone and minor conglomerate, siltstone)

S_{FR} Sedimentary rocks (Flume Ridge Fm.)

SILURIAN AND/OR OLDER

Felsic intrusive rocks (granitoid rocks and felsic porphyries)

ORDOVICIAN AND/OR SILURIAN

OS_{QB} Sedimentary rocks (Queen Brook Fm.)

ORDOVICIAN

O_S Sedimentary rocks (mainly dark grey to black siltstone, shale, and sandstone)

O_{VS} Mafic and felsic volcanic rocks and minor sedimentary rocks

ORDOVICIAN OR CAMBRIAN

$O\mathcal{E}_V$ Felsic volcanic rocks

CAMBRIAN

$\mathcal{E}_{SJ}$ Sedimentary and mafic volcanic rocks (Saint John Gp.)

$\mathcal{E}_{SV}$ Mafic and minor felsic volcanic rocks; minor sedimentary rocks (sandstone, siltstone, and minor conglomerate)

$\mathcal{E}_{VS}$ Mafic and minor felsic volcanic rocks; minor sedimentary rocks (sandstone, siltstone, and minor conglomerate)

LOWER CAMBRIAN AND PRECAMBRIAN

H_B Felsic and mafic volcanic rocks, and felsic and mafic intrusive rocks (Coldbrook Gp., Kingston Complex)

black shales characterize the unit. Unit O_{VS} is a facies equivalent of Unit O_S and contains thick successions of locally pillowed mafic, and felsic volcanic rocks interbedded with Unit O_S-type sedimentary rocks. Units O_S and O_{VS} are unfossiliferous, but lithological correlations with fossiliferous Ordovician rocks of the Cookson Formation (Ruitenberg 1967) along strike to the southwest establish their age.

A distinct sequence of sedimentary rocks, which lies generally to the southeast of the Cookson-type rocks, is also tentatively assigned to the St. Croix Terrane. These rocks comprise the Queen Brook Formation (Unit OS_{QB}) and are typified by light green to purple, thinly bedded and fine-grained quartzose sedimentary rocks with minor amounts of volcanogenic sandstone and orthoquartzite. Contacts between Units O_S and OS_{QB} are generally faulted, but intercalation occurs locally.

The relationship between Unit OS_{QB} and the Silurian rocks in the Nerepis Subbelt of the Mascarene Cover Sequence (see below), however, is uncertain. McCutcheon and Ruitenberg (1987) maintain that the contacts are gradational. This would indicate that continuous deposition occurred in this area, throughout Late Ordovician and Silurian time thus diminishing the relevance of the St. Croix Terrane as an entity, as presently defined. If the contacts are tectonic, however, the integrity of the terrane as presently defined would be maintained and the southern boundary would be delineated by a complex fault zone termed the Southern St. Croix Fault System.

Two fault-bound(?) units (Units $O\epsilon_V$ and S_{S3}) of unknown age also occur within the St. Croix Terrane. Unit $O\epsilon_V$, which contains red to grey felsic volcanic rocks, occurs to the north and apparently lies stratigraphically below Unit O_{VS}. Unit S_{S3}, which contains interbedded, light grey, quartz-rich sandstone and light to dark grey green siltstone, is unlike any other Ordovician rocks in the area, but resembles similar sedimentary rocks in the Nerepis Subbelt.

The Siluro-Devonian Mascarene Cover Sequence is subdivided into four, mainly fault-bound and distinct tectonostratigraphic subbelts (Figure 28). These include the Campobello, Ovenhead, Mascarene, and Nerepis subbelts, parts of which have been described in detail by McLeod and Rast (1988), Van Wagoner *et al*. (1988), Donohoe (1978), and McCutcheon and Ruitenberg (1987), respectively.

In the southwestern part of the project area (Figure 31), three of these subbelts (Campobello, Letete, and Ovenhead) are juxtaposed by a complex series of faults (McLeod and Rast 1988). The Campobello Subbelt is composed of mildly deformed, dark grey, pyritiferous turbidites and mafic volcanic rocks of the Quoddy Formation (Unit S_Q), which is inferred to lie

unconformably on Precambrian rocks. These rocks extend to the southwest into Maine, but have not been recognized elsewhere in New Brunswick.

The Letete Subbelt is intensely deformed and contains three fault-bound units (Figure 31). Dark green siliceous sandstone and siltstone comprise the basal unit (Unit S_{S1}), limestone underlain and overlain by mainly mafic volcanic rocks comprises the middle unit (Unit S_{LV}), and a mixed sequence of mafic and felsic volcanic rocks interbedded with dark grey to black fine-grained siltstone and sandstone comprises the upper unit (Unit S_{VS}). The felsic volcanic rocks that occur near the top and bottom of Unit S_{VS} may represent repetitive volcanism or define a regional antiformal structure (compare Ruitenberg 1968 and Donohoe 1978). This subbelt does not extend into Maine but does continue to the northeast into New Brunswick.

Detailed work has shown that interbedded sedimentary and mafic and felsic volcanic rocks to the northeast along the southern margin of the Saint George Batholith can be tentatively correlated with Unit S_{VS}. Fossiliferous siltstone, buff-weathering rhyolite and mafic tuffs, and agglomerate strike northeast and dip steeply northwest to vertical. Graded bedding within sedimentary units interbedded with rhyolite, indicates that beds are younging to the north. The sequence is variably mylonitized, and southwest of Fowle Lake, exhibits flaser structures.

A new fossil locality occurring in grey siltstone, west of Fowle Lake, contains a varied assemblage of bivalves and trace fossils not yet identified, but the rocks are strikingly similar to siltstone in Unit S_{VS}, which produced Pridolian fossils (Donohoe 1978). Felsic volcanic rocks in the Fowle Lake area are interbedded with tuffaceous rocks and grey siltstone similar to the fossiliferous rocks, which suggests a Silurian designation. Stretched pebble conglomerate and accretionary lapilli tuff, which occur in Unit S_{VS} to the southwest (Ruitenberg 1968; Donohoe 1978), were also observed in the Fowle Lake area. Currie (1988) correlated the unit with his "Fish Plant Beds" at Beaver Harbour, which yielded a non-specific Silurian age. A single brachiopod in black slate, east of Fowle Lake, however, suggests part of the unit could be Middle to Late Ordovician in age (Hay 1968).

Weakly to strongly deformed granite to diorite locally intrudes the Silurian sequence and contains numerous inclusions of mafic volcanic rocks in places. Although these granitoid rocks have recently been considered Late Precambrian to Cambrian in age (Currie 1988), the above relationships indicate that some, at least, are younger.

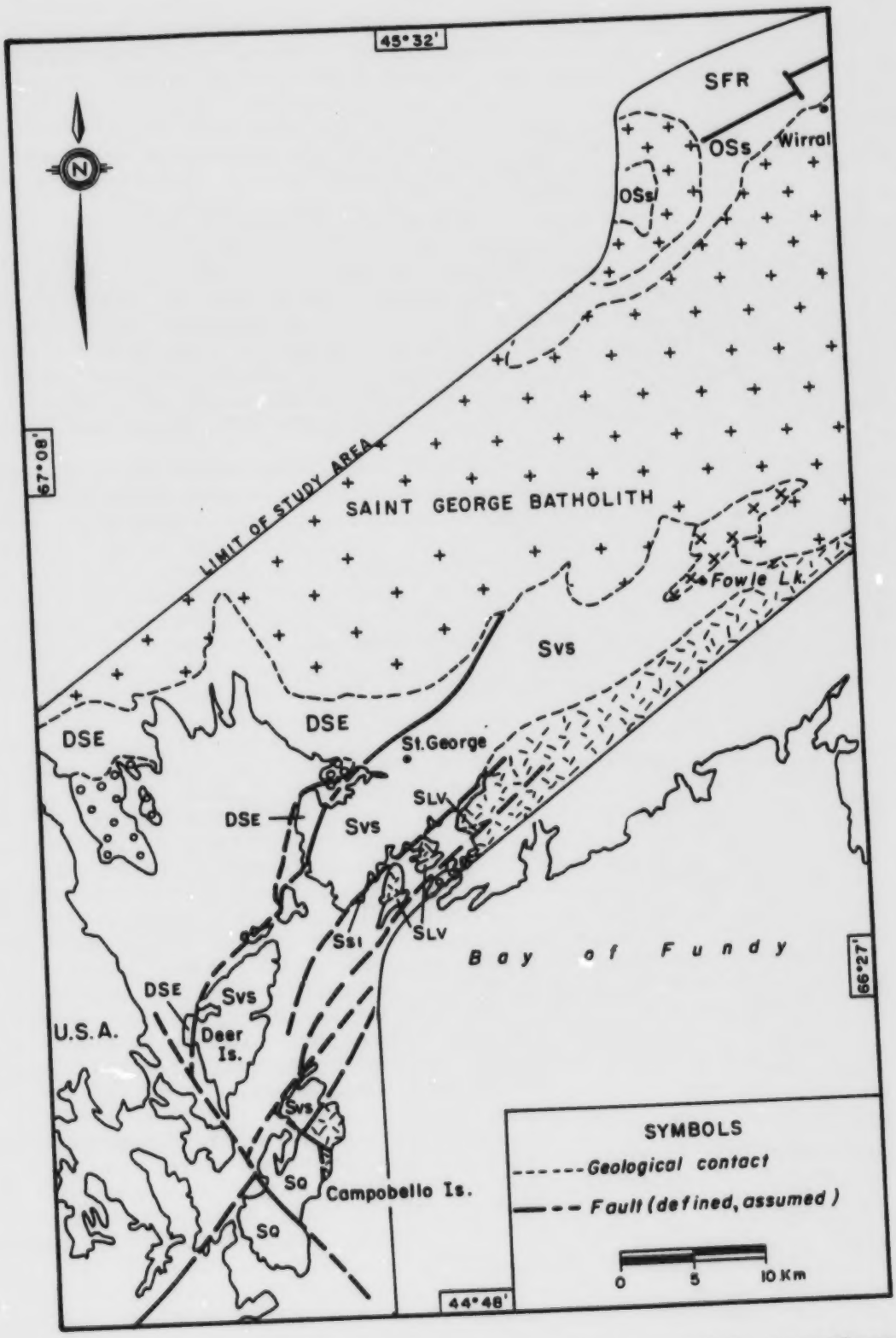

FIGURE 31. Geology of southwestern New Brunswick (southwestern portion).

LEGEND

DEVONIAN

Sedimentary rocks (Perry Fm.)

DEVONIAN AND SILURIAN

Granitoid rocks (Saint George Batholith)

DS_E Felsic and mafic volcanic rocks, and sedimentary rocks (Eastport Fm.)

SILURIAN

Granitoid rocks

S_{VS} Mafic and felsic volcanic rocks, and sedimentary rocks (siltstone and sandstone)

S_{LV} Limestone and mafic volcanic rocks

S_{S1} Sedimentary rocks (quartzose, sandstone and siltstone)

S_Q Sedimentary and mafic volcanic rocks (Quoddy Fm.)

S_{FR} Sedimentary rocks (Flume Ridge Fm.)

SILURIAN AND/OR OLDER

Granitoid and mafic intrusive rocks, and felsic volcanic rocks (Coldbrook Gp. equivalents(?), Silurian and/or Precambrian granites, Kingston Complex)

ORDOVICIAN AND SILURIAN(?)

OS_S Sedimentary rocks (siltstone, sandstone and minor conglomerate).

The Ovenhead Subbelt is composed of mildly deformed, cyclical sequences of mafic to felsic volcanic rocks and associated red to green sedimentary rocks (Unit DS_{VS}). The subbelt comprises the top of the Siluro-Devonian succession that extends to the southwest into Maine (Pickerill and Pajari 1976) and is truncated by the Saint George Batholith to the north.

The Nerepis Subbelt constitutes the Mascarene Cover Sequence in the northeastern part of the project area (Figure 30). West of the Saint John River, the subbelt is comprised of a variably deformed conformable sequence of predominantly mafic volcanic rocks and minor dark grey sedimentary rocks of the Long Reach Formation (Unit S_{LR}) overlain by light to dark green and grey fine- to medium-grained sedimentary rocks and felsic volcanic rocks of the Jones Creek Formation (Unit S_{JC}). Outliers south of the main Nerepis Subbelt, which contain grey polymictic conglomerate and associated fine-grained sedimentary rocks (Unit S_{CG}), are correlated with the Long Reach Formation and are interpreted to represent a Silurian unconformity.

East of the Saint John River (Figure 30), the Nerepis Subbelt is composed of light to dark grey, fine- to medium-grained sedimentary rocks and minor conglomerate (Unit S_{S2}). Distinctive rusty weathering quartzose sandstone characterizes this unit. It is overlain by mafic volcanic rocks correlated with the Long Reach Formation. Upper contacts of units in the Nerepis Subbelt are either faulted or unexposed. Lower contacts of the units are problematical and may be either faulted or gradational as described previously.

The northernmost inlier in the project area contains interbedded, light green and micaceous, fine- to medium-grained sedimentary rocks equivalent to the Flume Ridge Formation (Ruitenberg 1967) along strike to the southwest. These rocks are representative of the Fredericton Cover Sequence, which occurs north of the Pendar Brook Fault.

As a result of this year's work, the extent and nature of the terranes and cover sequences of southwestern New Brunswick have been traced as far as possible to the northeast in outcrop. Their extent beneath the Carboniferous cover rocks is traced across New Brunswick to Prince Edward Island (Fyffe, this volume). Of particular economic significance is the extension of the St. Croix Terrane, which includes the gold and base metal-bearing zones of the Annidale area, beneath a thin cover of Carboniferous rocks. Although metal-bearing fault structures mainly affect Lower Paleozoic rocks, late movements along these structures also affect Carboniferous strata locally. These factors underscore the importance of conducting detailed mapping and exploration programs in this area.

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THE LAKE GEORGE ANTIMONY-GOLD DEPOSIT, YORK COUNTY, NEW BRUNSWICK (MDA)

A. Caron and A.D. Roy, Project Geologists

The objective of the Lake George project is to define the structural controls of the antimony-gold deposit and apply this information in the evaluation of the mineral potential of the area. This year's work was concentrated on the structural relationships of the ore zone using drill core stored at the mine site. The orientation of the bedding within and outside the mine workings was established by using drill holes with different orientations. This made it possible to determine the general geometry of the folds within the mine area. Samples have been collected in order to study in more detail the alterations of the different rock types, the types of veins, and structural features such as cleavage types and brecciation and mylonitization.

L'objectif du projet du lac George est de définir les contrôles structuraux du gisement d'or-antimoine et d'appliquer cette information à l'évaluation du potentiel minier de la région. Le travail de cette année s'est concentré sur les relations structurales de la zone minéralisée en utilisant les carottes entreposées à l'emplacement de la mine. L'orientation des strates à l'intérieur et à l'extérieur des puits d'extraction fut établie en forant des trous d'orientations différentes. Ceci a permis de déterminer la géométrie générale des plis à l'intérieur de la région de la mine. Des échantillons furent recueillis afin d'étudier plus en détail l'altération des différents types de roches, les types de veines, et les caractères structuraux tels que le type de clivage et la formation de brèches et de mylonites.

This project continues the study undertaken by Roy (1989) of the Lake George antimony deposit. The deposit was mined until January 1990 by Dominion Explorers Inc. and the underground workings are now flooded. The purpose of this project is to study the structural controls of the deposit and complete the study with regional mapping to evaluate the mineral potential of the area.

The Lake George antimony deposit is a stibnite-gold-bearing quartz +/-carbonate vein system (Morrissy and Ruitenberg 1980) that cuts through Late Silurian greywacke and slate, and granodiorite associated with the Late Silurian - Early Devonian Pokiok Batholith (Lutes 1989; Bevier 1988). The Hibbard vein, the richest vein of the system, strikes roughly east-west with a dip of approximately 35 degrees to the north in the eastern workings of the mine, and veers to the west-northwest with an increase in dip to 40 to 50 degrees in the western workings of the mine (Figure 3 of Morrissy and Ruitenberg 1980).

Before the closure of the mine in January 1990, Angela Roy and Sheila Watters studied gold-bearing alteration in a short drift in the hanging wall of the Hibbard Vein, which is connected to the 850' level. Preliminary petrographic investigation shows that the colour change in the alteration zone, which changes from grey in the centre to dark brownish grey on the rim, mostly reflects the presence of carbonate (about 40%) in the grey alteration whereas the composition is dominated by quartz (about 55%) in the dark brownish grey alteration.

During the 1990 field season, more than 200 drill holes have been examined, which constitutes a fairly good representation of the 300 000 feet (91 400 m) of drill core stored at the mine site. Emphasis was placed on the alteration types and the structural relationships. Angular relationships between the bedding planes and the core axes were used in adjacent holes of different azimuth and/or plunge to establish the orientation of bedding within and outside the mine workings. Close to 100 samples of drill core were collected of the different bedrock, alteration and vein types, and of structural features such as cleavage, brecciation and mylonitization.

A south-to-north section of the deposit shows that the main ore zone dips about 35° north and is enveloped by an intense alteration zone of variable thickness (Figure 32). It is notable that the stibnite veins may be concentrated in upper or lower part of the alteration zone. In addition, there are some stibnite-bearing quartz veins that occur outside the main alteration zone but they appear to be discontinuous and associated with very narrow alteration zones.

Examination of the drill cores made it possible to define bedding planes within and outside the mine workings and assisted in the delineation of the axial surface of the anticline crossing the western workings of the mine.

Three types of sequentially emplaced metallic veins have been distinguished in the deposit. These include, respectively, stibnite-bearing quartz veins, molybdenite-scheelite-bearing veins, and gold-bearing quartz-carbonate veins.

The following alteration types can be distinguished from older to younger: skarn, sericitic, and sulphide-carbonate. The skarn alteration affects a wide area around the granodiorite stock and is characterized by a pale bluish green colour that locally forms stripes reflecting different alteration intensities. This alteration commonly follows bedding planes and affects the greywacke more than the siltstone (Seal 1984). The sericitic alteration is the main alteration surrounding the stibnite-bearing quartz veins. It is greenish grey or pale green, commonly contains dissiminated pyrite, and weathers yellow or brown. The sulphide-carbonate alteration commonly surrounds quartz-carbonate veins. This alteration is grey

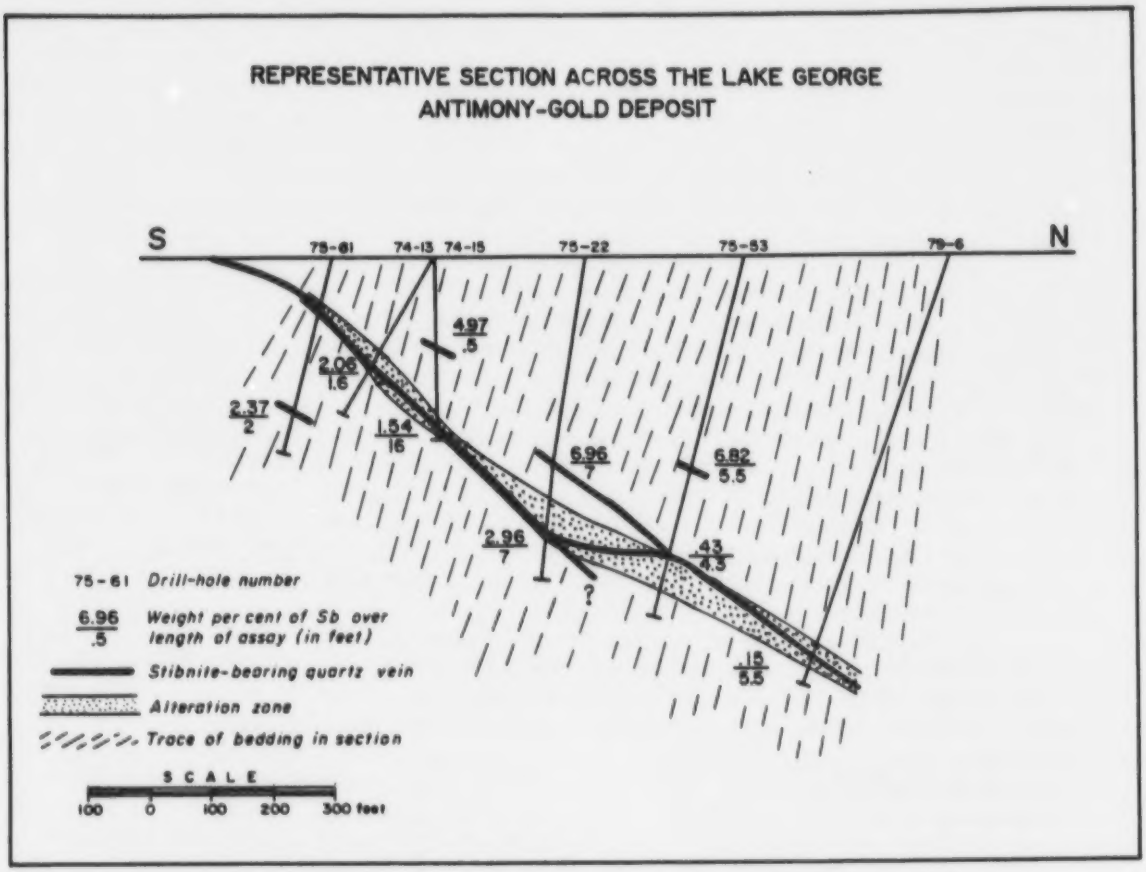

FIGURE 32. Representative section across (south to north) the Lake George antimony-gold deposit.

adjacent to the vein and yellowish green away from the vein. Pyrite and arsenopyrite are the most common sulphides in the alteration zone, but it also contains variable concentrations of gold. Gold is also associated with thin breccias a few centimetres thick, which are almost devoid of alteration.

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NEW BRUNSWICK MINERAL OCCURRENCE FILE (MDA)

D.G. Rose, Project Geologist

During the 1990 field season, David Rose, with the assistance of Donald Hebb, examined metallic mineral occurrences in the region west of Saint John to St. George and north to the South Oromocto Lake area. The objective of the field work was to accurately locate, describe, and sample the significant mineral occurrences in NTS map areas 21 G/1, 2, and 7 (Figure 33). Eighty-four occurrences documented in the Mineral Resources Division files were targeted for examination; of that number, seventy-two were successfully located. In addition, four previously discovered but undocumented occurrences were found or visited and an additional twelve sites, exhibiting alteration and/or pyrite mineralization were noted and sampled.

The results of the investigation will be incorporated into the existing hard copy and computerized files. The samples collected in 1989 and 1990, representing 125 occurrences in southern New Brunswick, will form a reference collection to accompany the Computerized Mineral Occurrence Database.

Sincere appreciation is extended to prospectors Bill Carter and Reginald Cox for their time and assistance; to Carman and Marvin Brawn, outfitters and guides, for their hospitality; and to colleagues Susan Johnson and Matthew Munn.

DOSSIER DES GITES MINÉRAUX DU NOUVEAU-BRUNSWICK (EDM)

D.G. Rose, géologue de projet

Au cours de la saison de terrain 1990, David Rose, avec l'aide de Donald Hebb, a examiné les indices minéralisés métalliques situés à l'ouest de la région allant de Saint John à Saint George, et au nord de la zone du lac Oromocto sud. Le but du travail sur le terrain était de localiser avec précision, de décrire et d'échantillonner les principaux indices minéralisés des régions des cartes NTS 21 G/1, 2 et 7. Quatre-vingt-quatre indices, décrits dans les dossiers de la Division des ressources minières, furent ciblés pour examen; de ce nombre, soixante-douze furent localisés avec succès. De plus, quatre indices qui avaient été précédemment decouverts mais non décrits furent localisés ou visités, et douze sites additionnels démontrant de l'altération et/ou de la minéralisation de pyrite furent inscrits et échantillonnés.

Les résultats de ces travaux seront incorporés à la copie sur papier et aux fichiers informatisés. Les échantillons recueillis en 1989 et 1990, représentant 125 indices situés

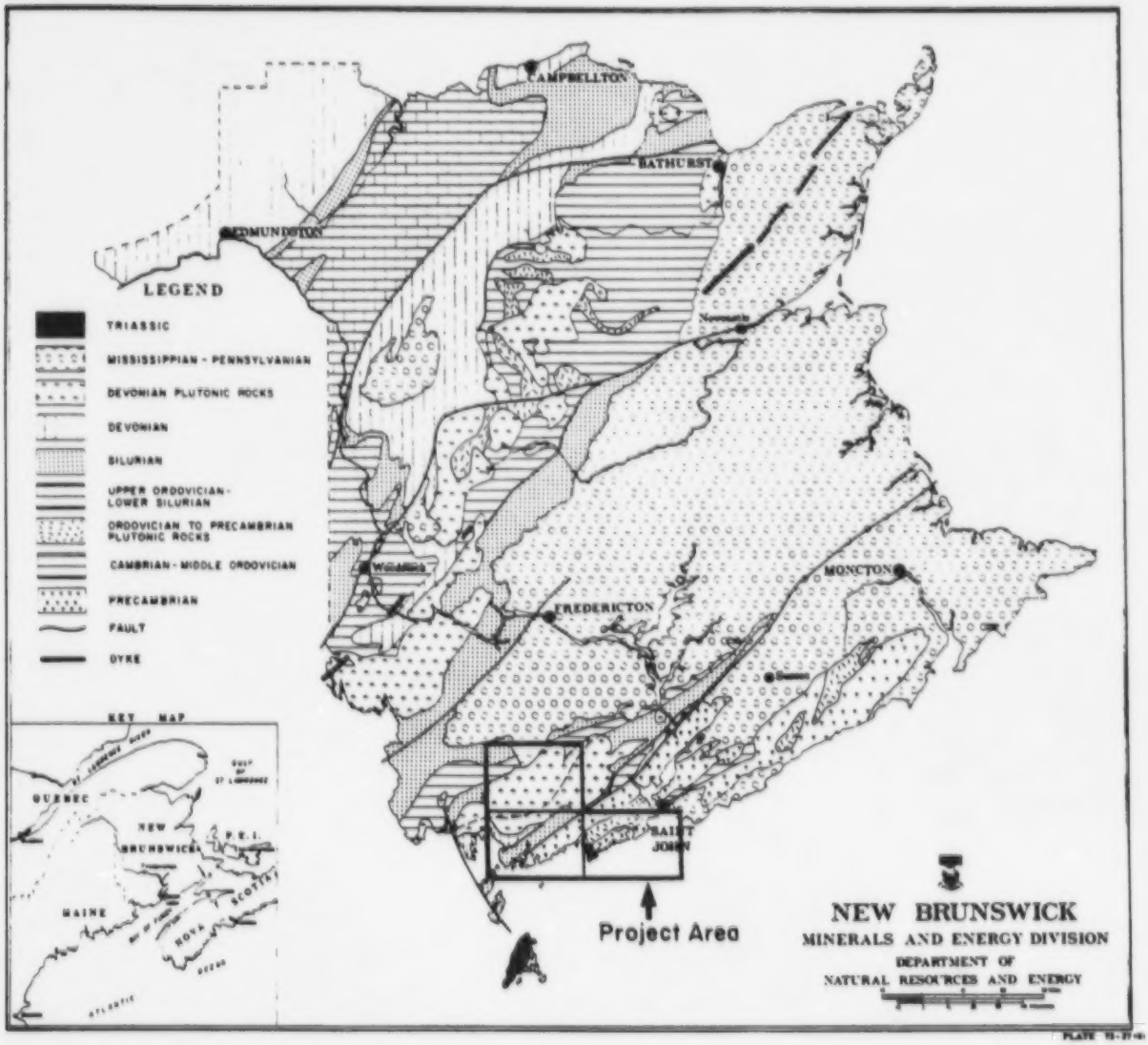


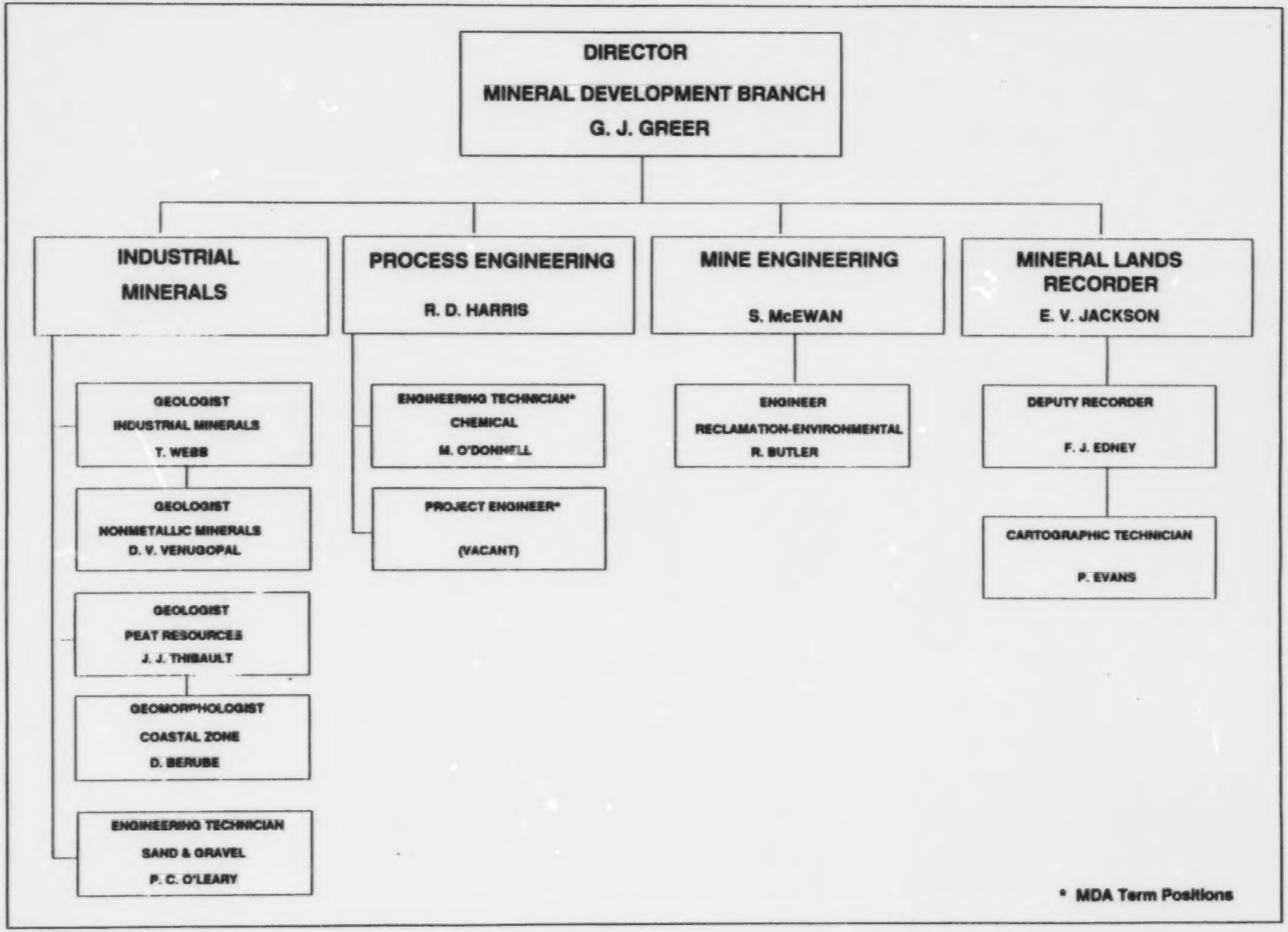
FIGURE 33. Index map for Musquash, St. George, and McDougall Lake map areas (NTS 21 G/1, 2, and 7).

dans le sud du Nouveau-Brunswick, formeront un ensemble de référence qui accompagnera la banque de données informatisée des gîtes minéraux.

Des remerciements sincères sont présentés aux prospecteurs Bill Carter et Reginald Cox pour leur temps et leur assistance; à Carman et Marvin Brawn, fournisseurs et guides, pour leur hospitalité; et à mes collègues Susan Johnson et Matthew Munn.

NOTES

MINERAL DEVELOPMENT BRANCH



Organization chart for Mineral Development Branch

MINERAL DEVELOPMENT BRANCH

INDUSTRIAL MINERALS SECTION

PEAT AND COASTAL ZONE RESOURCES (PROV)

Jacques J. Thibault, Geologist

PEAT

In 1990, three projects were being carried out:

1) Peatland Reclamation - Phase II.

The objective of this project, funded under the Canada - New Brunswick MDA (1984-1989), was to test silviculture, one of the peatland reclamation options identified in Phase I. The Peat Research and Development Centre of Shippagan was contracted to evaluate two test sites: one in Pointe-Sapin, for black spruce; the other in Rexton, for balsam fir. Site preparation was completed in the autumn of 1989 and planting of seedlings took place in June, 1990.

2) Air-quality monitoring program.

In order to better quantify and evaluate the impact of the peat industry on the quality of air, monitoring stations were set up at three different localities in northeastern New Brunswick: Lamèque, Shippagan, and Maisonnette. Environment Canada installed the equipment and will be analysing the filters. The Peat Research and Development Centre and Fisons Horticulture Corporation assist in the maintenance of the air samplers and the regular collection and replacement of air filters. Air quality is monitored for a 24-hour period every three days. The project, which began on June 10th, is scheduled to run until the end of 1990.

3) Peatland hydrology.

The objective of this study is to describe the basic hydrology of Bog 569 (Pigeon Hill), a typical peatland located in northeastern New Brunswick. A combination of field data acquisition and theoretical modelling will provide information on discharge, variations in pH and suspended solids, and water-table fluctuations. The project was awarded to Gemtec Limited of Fredericton. The N.B. Department of the Environment is assisting in the supervision of the project.

COASTAL ZONE

An additional staff member was hired to begin a five-year coastal mapping program aimed at producing a map atlas of the Northumberland Strait, Gulf of St. Lawrence, and Chaleur Bay coasts. The maps will provide a ready reference to deal with coastal resource management issues and problems. Mr. Dominique Bérubé has been hired to work on this project. His responsibilities are to document the geology, geomorphology, coastal processes and resources along the Province's shoreline. The 1990 field program covers a 50 km stretch of coast from the Nova Scotia - New Brunswick border in Baie Verte to Cape Jourimain. In addition, one specific portion of that coast (Cape Jourimain/PEI Ferry terminal area) will be the subject of a GIS coastal mapping pilot project.

TOURBE ET RESSOURCES LITTORALES

Jacques J. Thibault, géologue

TOURBE

En 1990, trois projets ont été mis à exécution :

1. Mise en valeur des tourbières - Phase II

   Ce projet, subventionné en vertu de l'entente Canada - Nouveau-Brunswick de développement minier (1984-1989), a pour but de vérifier les possibilités de la sylviculture, l'une des options de mise en valeur des tourbières identifiées au cours de la Phase I. Le Centre de recherche et de développement de la tourbe de Shippagan a été chargé par contrat d'évaluer deux terrains d'essai : un à Pointe-Sapin, pour l'épinette noire et l'autre à Rexton, pour le sapin blanc. La préparation des lieux a pris fin au cours de l'automne de 1989 et les plants ont été mis en terre au mois de juin 1990.

2. Programme de surveillance de la qualité de l'air

   Afin de mieux mesurer et évaluer l'impact de l'exploitation de la tourbe sur la qualité de l'air, des postes de surveillance ont été établis dans trois localités du nord-est du Nouveau-Brunswick : Lamèque, Shippagan et Maisonnette. Environnement Canada, qui a installé l'équipement, se charge de l'analyse des filtres. Le Centre de recherche et de développement de la tourbe et Fisons Horticulture Corporation aident à l'entretien des échantillonneurs d'air, ainsi qu'à la collecte et au remplacement réguliers des filtres. L'air est échantillonné sur une période de 24 heures tous les trois jours. Le projet, qui a démarré le 10 juin, devrait se poursuivre jusqu'à la fin de 1990.

3. Hydrologie des tourbières

L'objectif de la présente étude est de décrire les caractéristiques hydrologiques fondamentales de la tourbière 569 (Pigeon Hill), une tourbière type située dans le nord-est du Nouveau-Brunswick. Les données recueillies sur place, associées à une modélisation théorique, permettront d'étudier l'écoulement des eaux, les variations du pH et des solides en suspension et les fluctuations de la nappe phréatique. Le projet a été confié à Gemtec Limited de Fredericton. Le ministère de l'Environnement du Nouveau-Brunswick participe à la supervision du projet.

TOURBE ET RESSOURCES LITTORALES

Un nouvel employé vient d'être recruté, dans le cadre d'un programme quinquennal de cartographie côtière, pour produire un atlas des côtes du détroit de Northumberland, du golfe du Saint-Laurent et de la baie des Chaleurs. Outil de référence facile à consulter, cet atlas sera utile pour l'étude des questions et des problèmes de gestion des ressources côtières. On a donc retenu les services de M. Dominique Bérubé qui est chargé d'étudier la géologie, la géomorphologie et les ressources et phénomènes du littoral de la province. Le programme de 1990 portera sur 50 km de côte, à partir de la Baie Verte, à la frontière de la Nouvelle-Écosse et du Nouveau-Brunswick, jusqu'au cap Jourimain. De plus, une portion spécifique de cette côte (cap Jourimain/ terminus du traversier de l'Î.P.-É.) fera l'objet d'un projet pilote de cartographie côtière du Service d'information géographique.

MINERAL DEVELOPMENT BRANCH

MINE ENGINEERING SECTION

MINE ENGINEERING

S. McEwan, Mining Engineer

NEW MINE DEVELOPMENT

During 1989/90, mine development in the Province peaked and subsequently leveled off, following the trend in base-metal prices. A brief summary of new mining activity that has taken place in the Province during 1990 is given below:

East West Caribou Mines Ltd.:

Following the official opening East West Caribou Mines in June of 1989, the operation found itself with severe production and financial concerns, which resulted in the subsequent layoff of the majority of the work force in August 1989. This was followed by a period of restructuring both from a financial and ownership perspective in January 1990 the operation recommenced production. At that time, Bathurst Base Metals Inc. (controlled by British financier Howard Miller) held dominant interest in the operation.

Breakwater Resources Ltd. was contracted to manage the operation and subsequently sub-contracted J.S. Redpath to implement the proposed modifications to the mine plan. The revised plan included a change in mining method from cut-and-fill to open stoping, the sinking of a three-compartment 1000-foot shaft, and increasing daily tonnage to 2500 tonnes. The operation has exceeded planned daily production and is currently running at 2800 tpd. At this time, the mine contains proven reserves of 1.9 million tonnes, grading 7.93% zinc and 3.58% lead. In addition, there are 10 million tonnes of ore in the probable and possible categories.

In September of 1990, Breakwater secured 100% interest in the Caribou property through an amalgamation with Bathurst Base Metals. The merger was based on a share exchange that included one Breakwater share for 3.75 shares of Bathurst. The two companies agreed to restructure the mine's $30 million debt with two Australian banks and Breakwater has agreed to fund the development of the mine to completion.

On October 26, 1990 it was announced that East West Caribou Mines would shut down due to a significant decrease in the price of zinc, the current economic recession, and the Persian Gulf crisis. Any decision to restart the operation would be market driven. In addition to this, senior officials indicated that a capital expenditure of $15 million would be required to restart the operation. This expenditure is needed to further underground development and to increase mill production to 3000 mtpd. The immediate result of this announcement was the lay-off of 215 people over a three-week period.

Murray Brook Resources Ltd. (a wholly owned subsidiary of NovaGold Resources Ltd.):

On October 27, 1989 the Hon. Frank McKenna officially opened NovaGold's Murray Brook Mine. The Murray Brook deposit is a massive sulphide body with a gold-bearing gossan cap. The gossan contains approximately 1.7 million tons of ore grading 0.037 oz./ton gold, 1.49 oz./ton silver. The gossan is the zone currently being mined and initial processing results indicate a milling rate of approximately 1150 tpd and recoveries for gold in the +80% range. Both of these rates are in excess of the original design. The processing facility is one of only three in the world and has features that enhance both its efficiency and environmental integrity. Because it is totally enclosed, ore can be leached on a year-round basis and airborne or liquid effluent from the operation is strictly controlled.

By January 1990, Murray Brook had produced 1000 kg of gold dore and by September had produced 13 393 ounces of gold and 87 934 ounces of silver. As previously stated, initial rates and recoveries were in excess of design, however, because of cold ore in the winter months, recoveries in the extraction process were in the order of 50% for January and February. Murray Brook is presently reviewing, in conjunction with the New Brunswick government, the possibility of an ore preheater to overcome this problem; initial results appear promising. During the warmer months of the year, recoveries were in the 85% range.

In addition to present gold production, NovaGold embarked on an exploratory review of the copper portion of the sulphide deposit. Drilling was performed in advance of the mining of the present open pit and initial results indicate that there are approximately 330 000 tons grading 4.68% copper. The feasibility of processing the copper is currently under review by the company and the federal government. If results of this study are positive, then mining the copper portion of the deposit will be considered.

Heath Steele Mines (a division of Brunswick Mining & Smelting):

On February 20, 1989 a decision was made by Noranda to proceed with the reopening of Heath Steele Mines. Heath Steele is a division of Brunswick Mining and Smelting Corp. Ltd. with both Brunswick and Noranda maintaining controlling interest in the operation. The fact that Heath Steele will be able to share some common facilities with Brunswick was a major factor in the reopening of the mine.

The commissioning of the Heath Steele mill began in September, 1989 with a design capacity of 2200 mtpd and mill feed coming from three zones on the property (Stratmat, B-Zone, & E-Zone). Initial results were not encouraging, however, the situation soon improved significantly with the mill reaching

consistent operating rates of 2900 mtpd. The mill is being supplied from two ore zones (B-Zone and Stratmat), with two more scheduled to be developed (E-Zone and A-,C-,D-Zones). This will give the operation a current mine life of seven years, up two years from the original five. Products include a zinc and a bulk concentrate destined for Europe, lead concentrate for the Belledune smelter and Europe, and a copper concentrate for the Noranda smelter in Valleyfield, Québec.

Employment on the site is 280 persons, as compared to 600 during the pre-shutdown period in the early 1980's, reflecting a dramatic increase in productivity. The original capacity of the mill prior to its shutdown in 1983 was 3500 mtpd and with this potential for extra production, Heath Steele is in a position to consider custom milling of other local ores, as a means to improve profits and ultimately prolong the life of the operation. This, combined with Heath Steele's active exploration program, could see the mine life extended well into the next century.

Marshall Minerals Corp. (Restigouche Deposit):

After acquiring the mineral rights to the Restigouche deposit in March of 1988, Marshall Minerals embarked on an extensive drilling program to further define reserves and processability of the ore. Results proved favourable and in February 1989, Marshall registered for screening under N.B.'s Environmental Impact Assessment Regulation and was subsequently screened in. The deposit is situated on Charlotte Brook, which runs into Upsalquitch Lake, a well known sport fishing area in a relatively undisturbed part of the Province. Marshall completed their EIA Report for the project and subsequently received a positive response in August 1990, from the Lieutenant Governor in Council to proceed with the development of the project. A security of $1.6 million will be required to ensure the environmental integrity of the operation.

The deposit is not large enough to support a mill, so the company hopes to enter into an agreement with a local mill to process the Restigouche ore. It is expected to cost about $3 million to bring the property into production, which would bring Marshall's total cost up to $5 million. Production would probably run at about 1500 mtpd from an open-pit operation, employing 50 people for a period of four years. Drilling indicates 1.2 million tonnes of ore grading 0.35% copper, 5.96% lead, 7.71% zinc, 3.62 oz./ton silver and 0.035 oz./ton gold. Marshall is currently in the process of obtaining other required government approvals before making a production decision.

Stratabound Minerals Corp. (Captain North Extension - CNE):

In December, 1987 Stratabound obtained the mineral rights to the Captain North Extension deposit, located approximately seven miles from the Heath Steele property. During 1988/89, drilling and trenching programs were carried out with very positive results indicating a high-grade, low-tonnage, zinc/lead/copper/silver deposit, located very close to surface (6 m). Initial bench-scale metallurgical tests indicate high recoveries and acceptable grade concentrates. Based on these results, Stratabound registered the project under the Environmental Impact Assessment Regulation and the project was subsequently screened out with conditions.

Following the positive EIA screening decision, Stratabound applied to the Department of Natural Resources and Energy to remove a 12 000-tonne bulk sample to test the metallurgy of the ore. The bulk sample was removed in September and milled at the nearby Heath Steele Mines facility with results proving quite successful. Based on production statistics, the average grade of ore over the five-day mill run was 5.5% lead, 12.0% zinc, and 5.0 oz./ton silver. Discussions are proceeding with Heath Steele Mines concerning a 1991-92 milling contract and a feasibility study to confirm the economic viability of the Captain North Extension is underway. As well, Stratabound is in the process of obtaining other required government approvals before making a production decision.

MINE RECLAMATION

R. Butler, Mine Reclamation Engineer

Through the New Brunswick Mining Act and its regulation, all developing mining operations are required to implement a program for the protection, reclamation, and rehabilitation of the environment. The reclamation plan is considered part of the Mine Feasibility Study and is developed during the initial design phase of a mining project. If the reclamation plan is properly engineered it may prevent major environmental impacts from occurring and will result in a mine site that is more readily rehabilitated at a much lower cost to the mining company.

In the administration of the Mining Act, mine reclamation engineering involves:

1) Inspection of existing mining operations in the Province; review of their reclamation practices; and technical support for reclamation programs.
2) The analysis and review of new mining projects in the Province; review of feasibility studies with emphasis on reclamation and rehabilitation; liaison between Natural Resources and Energy and the Department of Environment for assistance in the review of reclamation plans.

Since November 1989, there has been one Reclamation Plan approval issued to Dickenson for their Havelock operation and there are presently three programs under review. The Branch has been involved in the Environmental Impact Assessment for the Marshall Minerals project and the EIA Screening for; (1) an expansion at Murray Brook, (2) testing at the Beersville Coal field, and (3) the possible reopening of the Hillsborough Gypsum quarry.

Reclamation engineering also involves research into methods of alleviating the environmental impact of existing or closed mining operations. The main factors apparent at abandoned mine sites include; reactive acid tailings and mine rock, site safety, and general land rehabilitation.

The Province has representation on the Mine Environment Neutral Drainage (MEND) committee and provides financial and technical support through various Provincial reclamation programs. Provincial support was given to Brunswick Mining and Smelting to investigate the effect of capping acid-generating waste-rock piles at their Heath Steele Mines operation. The Province is also involved in a reclamation research program for abandoned Peatlands.

RÉAMÉNAGEMENT MINIER

R. Butler, ingénieur minier

Par l'entremise de la Loi sur les mines du Nouveau-Brunswick et de ses règlements, toutes les opérations minières présentement en développement doivent implanter un programme pour la protection, le réaménagement et la revitalisation de l'environnement. Le plan de réaménagement est considéré comme faisant partie de l'étude de faisabilité minière et est élaboré durant la phase de conception préliminaire d'un projet minier. Si le plan de réaménagement est bien conçu il pourra prévenir des problèmes environnementaux majeurs et resultera en un site minier plus apte à être revitalisé à un coût beaucoup moindre pour la compagnie minière.

Dans l'administration de la Loi sur les mines, le réaménagement minier implique :

1) l'inspection des sites miniers en opération dans la province, l'examen des pratiques de réaménagement, et un soutien technique pour les programmes de réaménagement;
2) l'analyse et l'évaluation des nouveaux projets miniers dans la province, l'examen des études de faisabilité mettant l'accent sur le réaménagement et la revitalisation, et la liaison entre le ministère des Ressources naturelles et de l'Énergie et le ministère de l'Environnement pour obtenir une assistance dans l'évaluation des plans de réaménagement.

Depuis novembre 1989, il y a eu une approbation dans la cadre du Plan de réaménagement émise à Dickenson pour leur opération de Havelock et il y a présentement trois programmes à l'étude. La section a été impliquée dans l'évaluation d'impact sur l'environnement (EIA) pour le projet de Marshall Minerals et la procédure d'approbation de l'EIA pour : 1) un agrandissement à Murray Brook, 2) un programme d'exploration du bassin houiller de Beersville, et 3) la réouverture possible de la carrière de gypse de Hillsborough.

Le réaménagement minier implique aussi de la recherche au niveau des méthodes visant à réduire l'impact environnemental aux sites miniers, opérationnels ou non. Les facteurs les plus manifestes aux sites de mines abandonnées incluent : les rejets de concentrateurs et les amas de stériles chimiquement actifs, la sécurité des sites et la revitalisation générale des terres environnantes.

La province est représentée au Comité de neutralisation des eaux et du drainage dans l'environnement minier (NEDEM) et fournit un soutien technique et financier par l'entremise de divers programmes provinciaux de réaménagement. Un support gouvernemental a été donné à Brunswick Mining and Smelting pour l'étude du développement des chapeaux de fer sur les amas de stériles chimiquement actifs à la mine de Heath Steele. La province est aussi impliquée dans un programme de recherche en réaménagement des tourbières abandonnées.

NOTES

MINERAL DEVELOPMENT BRANCH

PROCESS ENGINEERING SECTION

PROCESS ENGINEERING

R. Harris, Senior Engineer

The process engineering sector was involved in many process and other related activities over the year. These included an assessment of technologies for the recovery of gold from heap leach solutions at Cape Spencer and the conversion of BM&S' waste phosphogypsum to potassium sulphate. Other activities include the recovery of fine potash using column flotation, the administration of the Mineral Investment Stimulation (MISP) and Mineral Processing Investigations Programs as well as promotional work relating to the manufacture of potassium sulphate from indigenous potash and gypsum. Two MISP contracts were approved; the first is a gold recovery versus temperature study at the Murray Brook operation and the other is a development assessment of the Antinouri Lake granite deposit.

Le secteur du génie des procédés a été impliqué dans plusieurs méthodes de traitement et autres activités connexes au cours de l'année. Celles-ci ont inclus une évaluation des technologies liées à la récupération de l'or par solutions de lessivage en tas au Cap Spencer et la conversion des déchets de phosphogypse de la BM&S en des sulphates de potassium. Les autres activités ont compris la récupération de potasse fine par colonnes de flottation, l'administration du Programme de stimulation de l'investissement minier (PSIM) et du programme de recherche en traitement de minérais, de même que du travail de promotion lié à la production de sulphate de potassium à partir de potasse et de gypse locaux. Deux contrats PSIM ont été approuvés; le premier est une étude sur la récupération de l'or en fonction de la température au site de Murray Brook, et l'autre, une étude de mise en valeur du dépôt granitique du lac Antinouri.

Several projects were carried out over the past year that involved the process engineering sector. These were funded wholly or in part under the first and second Canada-New Brunswick MDAs; and these are summarized in the following:

1. Recovery Options For Cape Spencer Gold

This study, which was wholly funded under the MDA (1984-89), was contracted to and carried out by the Research and Productivity Council (RPC) of Fredericton.

The objectives were to characterize the Cape Spencer gold deposit(s), to review existing and developing technologies for gold extraction and recovery, and assess their effectiveness based on laboratory test work. The technical results were used to make a preliminary economic assessment of those (technologies) tested.

Bench-scale tests of the various recovery processes showed that carbon adsorption and solvent extraction gave the highest recoveries of around 97%. Zinc precipitation was relatively inefficient at low gold loadings; recovery was low and zinc dust consumption was high. Direct electrowinning gave gold recoveries in the order of 70% from the heap-leach solutions.

Preliminary capital costs for a 250 000 heap-leach operation using carbon adsorption as the recovery process were estimated to be $1.4 million (+/- 30%).

2. Column Flotation of Fine Potash

This was a cost-shared study between RPC and the Mines Division and was carried out by RPC in cooperation with Denison-Potacan and PCA, who provided technical and operational support during the in-plant test trials.

Column flotation is gaining prominence as a potentially effective means of recovering fines that are not usually recoverable by conventional agitated flotation. Losses of fine potash to tailings are quite significant with the potash operations and are becoming a focus point for possible improvements. This study evaluated the application of column flotation to both the Dension-Potacan and PCA operations in the Sussex area.

Results obtained at both plants indicate that column flotation may give better grades and recoveries with lower insoluble levels relative to their conventional flotation practice.

3. Mineral Investment Stimulation Program

The objective of MISP is to provide financial assistance to the provincial minerals industry for the purpose of stimulating further private sector development of the industry. The program was initiated under the last Mineral Development Agreement and is again proposed as part of the work program slated for the next MDA.

Two studies have been approved to date in this fiscal year. The first is a gold recovery versus temperature study at the Murray Brook operation in northern New Brunswick. Murray Brook experienced a marked reduction in gold recovery over the last winter. Therefore, this study was proposed in co-operation with RPC to review the foregoing as a basis for improving the process by the possible installation of an ore heating system for winter operation.

The other is a development assessment study by MUNITEK of the Antinouri Lake granite deposit in northern New Brunswick. Three-D Geoconsultants of Fredericton were subcontracted by MUNITEK to carry out the complete study in three phases: 1. Determination of potential product specifications; 2. Analysis of markets and transportation; and 3. Development plan and financial analysis.

4. Mineral Processing Investigations Program

The work program for this year consists of one study entitled, "Potassium Sulphate Manufacture using BM&S' Waste Phosphogypsum". The testing component of this study is being carried out in the mineral processing laboratory of the Mineral Resources Division.

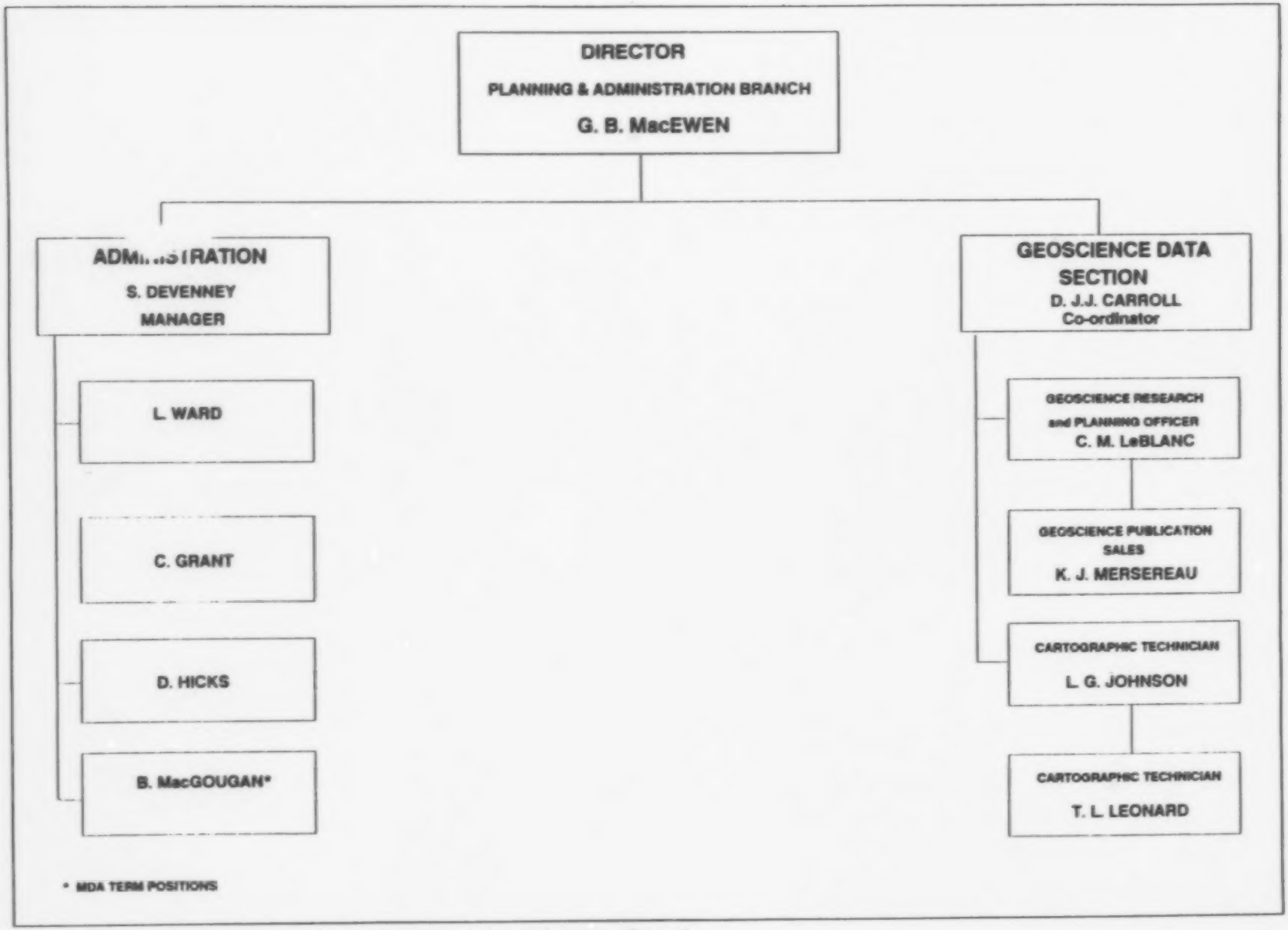
BM&S' current practice of dumping waste phosphogypsum generated by the smelter/fertilizer plant complex into the Bay of Chaleur at a rate in excess of 300 000 tonnes per year is now the cause of increasing environmental concern. Application of this material as a gypsum feedstock for the manufacture of potassium sulphate would both reduce such concern and provide a low cost feedstock for the process.

Test work to date has included the reaction of potash with phosphogypsum to form potassium sulphate and calcium chloride. Preliminary results are encouraging in that significant reaction was observed. However, work is continuing in an effort to develop a possible flowsheet for treating the phosphogypsum.

5. Potassium Sulphate Manufacture

This is a study that has been on going for the last five years. The activity in this year included an update of the marketing and economic components (by P.J. Whalen and R.J. Hollingshead & Associates) along with promotional work with the aim of encouraging further development by private industry.

PLANNING AND ADMINISTRATION BRANCH



Organization chart for Planning & Administration Branch

PLANNING AND ADMINISTRATION BRANCH

GEOSCIENTIFIC INFORMATION SECTION

ACTIVITIES OF THE GEOSCIENCE DATA SECTION

D.J.J. Carroll, Coordinator

The Geoscience Data Section consists of the following staff members: Donald J.J. Carroll (Coordinator), L. Gerard Johnson (Cartographic Technician), Terry Leonard (Cartographic Technician), Ken Mersereau (Geoscience Publication Sales), and Carol M. LeBlanc (Exploration Assessment Data).

The Section is responsible for providing a variety of geoscientific, technical, and support services to the staff of the Minerals and Energy Division. In addition, the staff of the Section provide assistance to the public, in particular the mineral industry, by supplying publications on the geology and mineral resources of the Province.

The Geoscience Data Section is made up of Geoscientific Cartographic Services and Geoscientific Information Services.

The distribution of geoscience publications from the Fredericton office in 1990 totalled 6560 maps and reports. The majority of these sales were to individuals working for the mineral exploration industry.

ACTIVITÉS DE LA SECTION DES DONNÉES GÉOSCIENTIFIQUES

D.J.J. Carroll, coordonnateur

La Section des données géoscientifiques comprend le personnel suivant : Donald J.J. Carroll (coordonnateur), L. Gerard Johnson (technicien de cartographie), Terry Leonard (technicien de cartographie), Ken Mersereau (vent des publications géoscientifiques) et Carol M. LeBlanc (évaluation des données d'exploration).

La Section doit fournir une foule de services géoscientifiques, techniques et de soutien au personnel de la Division des ressources minérales et de l'énergie. En outre, le personnel de la Section doit offrir au public, et plus particulièrement aux représentants de l'industrie minière, des publications portant sur la géologie et les ressources minérales de la province.

La Section des données géoscientifiques comprend les services de cartographie géoscientifique et les services d'information géoscientifique.

Au cours de l'année 1990, les publications géoscientifiques distribuées par le bureau de Fredericton ont totalisé 6560 cartes et rapports. La plupart des publications ont été vendues à des particuliers travaillant dans l'industrie de l'exploration minière.

PART II

GEOLOGICAL SURVEY OF CANADA

CONTRASTING PETROCHEMISTRY AND AGE OF PLUTONIC ROCKS IN THE SAINT JOHN AREA AND CALEDONIAN HIGHLANDS KINGS AND SAINT JOHN COUNTIES, SOUTHERN NEW BRUNSWICK (MDA)*

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Plutonic rocks in the Saint John area and east through the Caledonian Highlands are divided into four main groups on the basis of petrochemistry and age: (1) calc-alkalic I-type dioritic to granitic plutons such as the Point Wolfe River and Cape Spencer plutons that range in age from ca. 610 - 630 Ma; (2) ca. 550 Ma bimodal suites such as the Bonnell Brook and Upham Mountain plutons that consist mainly of syenogranite with subordinate dioritic rocks and are co-genetic with widespread rhyolite and basalt units; (3) gabbroic plutons, such as Mechanic Settlement and Duck Lake that may be similar in age to the bimodal plutonic suites (ca. 550 Ma); (4) ca. 560 - 530 Ma dioritic to granitic plutons that intruded the Green Head Group and Brookville Gneiss in the Saint John area.

Les roches plutoniques de la région de Saint John et des collines calédoniennes situées plus à l'est se divisent en quatre grands groupes, selon leur composition pétrochimique et leur âge : (1) les plutons dioritiques et granitiques calco-alcalins de type I, comme les plutons de la rivière Point Wolfe et du cap Spencer dont l'âge varie de 610 à 630 Ma (millions d'années); (2) les ensembles bimodaux d'environ 550 Ma comme les plutons de Bonnel Brook et du mont Upham, principalement formés de syénogranite avec des roches dioritiques sous-jacentes, qui sont de la même période que la rhyolite et le basalte si répandus; (3) les plutons gabbroïques, comme ceux de Mechanic Settlement et de Duck Lake, qui pourraient avoir le même âge que les ensembles plutoniques bimodaux (env. 550 Ma); (4) les plutons dioritiques et granitiques de 560 à 530 Ma qui ont pénétré le groupe Green Head et le gneiss de Brookville dans la région de Saint John.

INTRODUCTION

Varied plutonic rocks occur in the area extending from Saint John eastward through the Caledonian Highlands of southern New Brunswick (Figure 34). In the Saint John area, the plutonic rocks have been termed the Golden Grove Suite or Golden Grove Intrusives, with individual pluton names assigned to some units (Cumming 1916; Hayes and Howell 1937; Alcock 1938; Wardle 1978; Ruitenberg et al. 1979; Currie et al. 1981; Williams et al.

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*Contribution to the Canada-New Brunswick Mineral Development Agreement, 1984-89 and the Canada New Brunswick Cooperation Agreement on Mineral Development, 1990-95. Project carried by the Geological Survey of Canada. Also funded in part by Natural Sciences and Engineering Research Council of Canada and Acadia University.

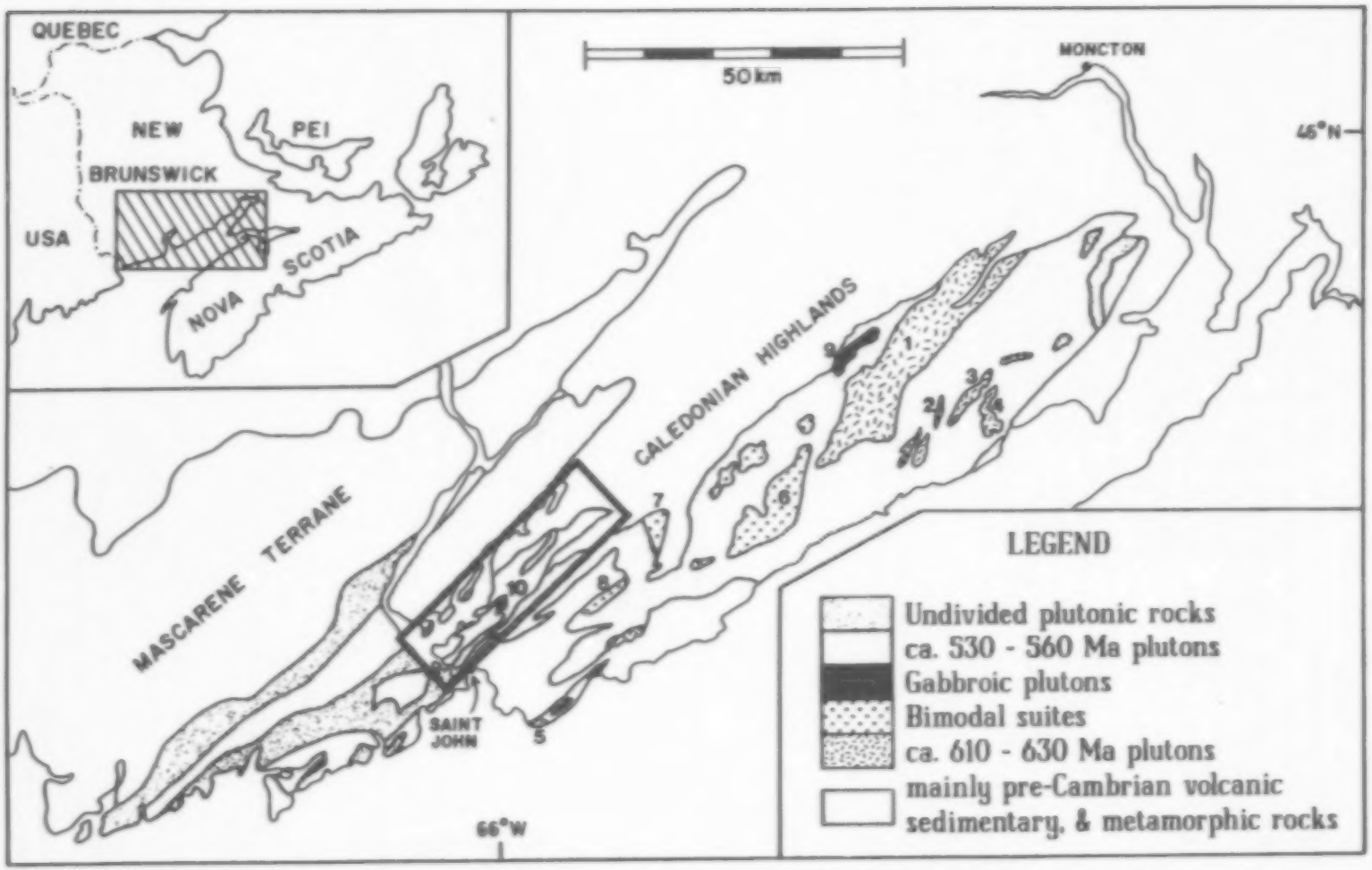

FIGURE 34. Map of southern New Brunswick showing the distribution of plutons in the Saint John area and Caledonian Highlands. Areas without patterns are Cambrian and younger rocks. Area of Figure 35 is shown in box. Plutons named in text are numbered: 1 = Point Wolfe, 2 = Goose Creek, 3 = Forty Five River, 4 = Alma, 5 = Cape Spencer, 6 = Bonnell Brook, 7 = Upham Mountain, 8 = Baxters Mountain, 9 = Mechanic Settlement, 10 = Duck Lake.

1985). Farther east in the Caledonian Highlands, separate plutons have been mapped and named (Ruitenberg et al. 1979). Different interpretations have been made about the age of these plutonic rocks. Some early workers considered them to be Precambrian (e.g., Bailey et al. 1880), but others considered them to be post-Silurian (e.g., Matthew 1894; Cumming 1916). Alcock (1938) suggested that they may be of two ages, Precambrian intruding the Green Head Group and possibly as young as Devonian in the Coldbrook Group. Kindle (1961) designated them as Precambrian and/or Palaeozoic. A number of K-Ar and Rb-Sr dates added to the uncertainty, leading Ruitenberg et al. (1979), for example, to conclude that plutons associated with the Green Head Group range from Late Precambrian to Early Palaeozoic whereas various intrusions in the Coldbrook Group are either Early Ordovician or older, Late Silurian to Early Devonian, or Carboniferous. In a very influential paper based on Rb-Sr and U-Pb (zircon) work, Olszewski and Gaudette (1982) concluded that the Golden Grove Suite formed at about 800 Ma, providing a minimum age for the associated Brookville Gneiss and Green Head Group.

As part of the re-mapping of the Saint John area and the Caledonian Highlands east through Fundy National Park (Barr 1987, 1988; Barr and White 1988a, b, 1990), we are using field relations, petrochemistry, and geochronology to better define the plutonic rocks of this area. Although this work is continuing, we can divide the plutonic rocks in our map area (Figure 34) into four main groups, as described below.

CALC-ALKALIC I-TYPE SUITES (ca. 610 - 630 Ma)

Plutons in this group range in composition from diorite through quartz diorite, tonalite, granodiorite, and granite. The largest is the composite Point Wolfe River Pluton (Figure 34), the two main units of which have been dated by U-Pb (zircon): Pollett River granodiorite at 625 ± 5 Ma, and the Old Shepody Road granite at 615 ± 1 Ma (Bevier and Barr 1990). Other plutons assumed to be of similar age on the basis of petrological features include the Goose Creek Leucotonalite and the Alma and Forty Five River plutons (Barr 1988; Barr and White 1988a, b). Small highly sheared plutons in the coastal region southeast of Saint John, including the Cape Spencer granite, are also considered part of this group, based on compositional similarity and the U- Pb date of 625 ± 15 Ma reported by Watters (1987) for the Cape Spencer body.

These plutons have petrological features characteristic of I-type calc-alkalic suites formed in association with subduction zones at a continental margin (Barr and White 1988b; Pitcher 1987). They may have formed during the same tectonic event as the calc-alkalic volcanic rocks of the Caledonian Highlands (Sequence A of Barr and White 1988b; Bevier and Barr 1990).

BIMODAL SUITES (ca. 550 Ma)

Distinctive syenogranitic plutons with associated but less abundant dioritic rocks are widespread in the Caledonian Highlands. The largest of these, the Bonnell Brook Pluton, has yielded a U- Pb (zircon) age of 550 ± 1 Ma (Bevier and Barr 1990). Others include the Upham Mountain Pluton (Germaine Brook granite of Alcock 1938) and the Baxters Mountain Pluton (Otter Lake pluton of Ruitenberg et al. 1979).

These are high-level plutons, commonly with granophyric texture in the syenogranitic parts and abundant miarolitic cavitities. In small bodies north of the main Bonnell Brook Pluton, fine-grained intrusive syenogranite can be traced into a subvolcanic rhyolite dome (Barr and White 1988a), and the age of the Bonnell Brook syenogranite is the same as the age of 548 ± 1 Ma reported by Bevier and Barr (1990) for rhyolite flows that, together with amygdaloidal basalt flows, are a major component of the volcanic rocks in the Caledonian Highlands. Hence the high-level subvolcanic bimodal plutonic suites are interpreted to be co-genetic with these compositionally similar bimodal basalt-rhyolite units.

GABBROIC PLUTONS (ca. 550 Ma ?)

The largest gabbroic pluton is the Mechanic Settlement Pluton, but other smaller gabbroic plutons occur widely, including Duck Lake near Saint John (Figure 34). Many of these are too small to be shown at the scale of Figure 34. None has been dated by U-Pb methods, but amphibole from the Mechanic Settlement gabbro has yielded a K-Ar date of 518 ± 37 (Barr and White 1988b). Because similar gabbros occur as a minor rock type in association with dioritic and syenogranitic rocks in the Baxters Mountain Pluton, the gabbros may be related to the ca. 550 Ma bimodal syenogranite-diorite suites. The Mechanic Settlement Gabbro is a layered body that ranges in composition from gabbro to diorite and granodiorite and has economic potential for platinum-group elements (Barr and White 1988b; Paktunc 1990).

DIORITIC TO GRANITIC PLUTONS, SAINT JOHN AREA (ca. 560 - 530 Ma ?)

Plutonic rocks in the Saint John area intruded the Green Head Group and Brookville Gneiss (Figure 35). Because of inconsistencies in the literature concerning the naming and composition of these units, we have done detailed mapping, petrological studies, and geochronology to better define these plutons (White and Deveau 1989; Deveau 1989; White et al., in review). The maximum age of these units is constrained by the ca. 605 Ma igneous age of the orthogneissic component of the Brookville Gneiss (White et al. 1990, in press; Bevier et al., in press; Dallmeyer et al., in press), and the age of its amphibolite-facies metamorphism (564 ± 6 Ma; Bevier et al., in

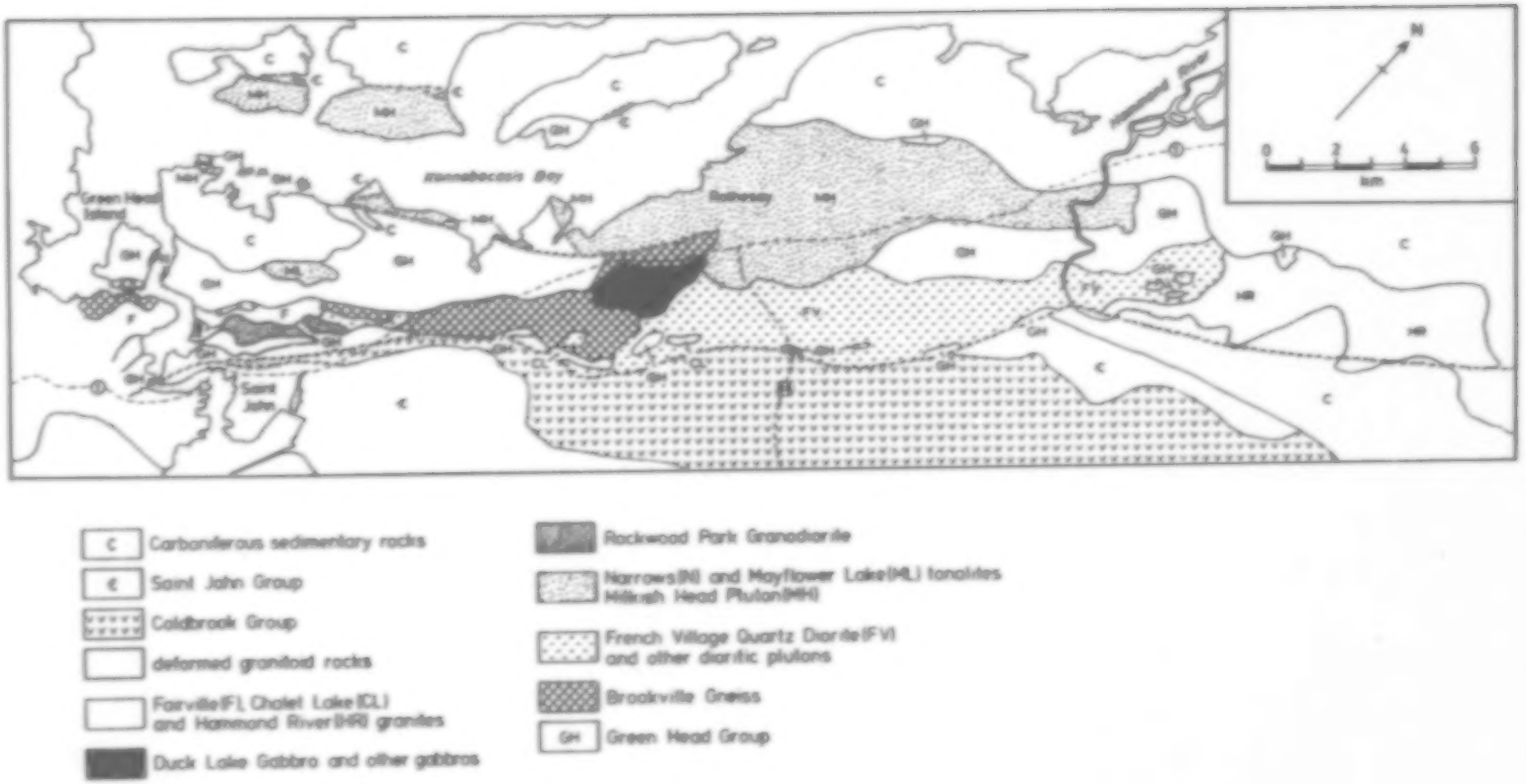

FIGURE 35. Detailed geological map of the Saint John area, east of the Saint John River.

press) because these plutons are post-metamorphic. Their age is further constrained by the crystallization age of 538 ± 1 Ma (U-Pb, zircon and titanite) for the Rockwood Park Granodiorite (White et al., in review). The Rockwood Park Granodiorite is intermediate in intrusive sequence between the French Village Quartz Diorite and related dioritic plutons and the Milkish Head Pluton, Duck Lake Gabbro, and Fairville, Chalet Lake, and Hammond River granites (Figure 35). Except for the Duck Lake Gabbro, these units form a calc-alkalic I-type suite that appears to be significantly younger than the compositionally similar suites in the Caledonian Highlands.

Deformed granitoid rocks of compositions similar to the various plutonic units also occur in the Saint John area (Figure 35). Because of their degree of shearing it is usually difficult to assign them with certainty to any particular pluton.

CONCLUSIONS

Plutons in the Saint John area and the Caledonian Highlands are divisible into four groups on the basis of composition and age. However, more U-Pb dating is required to further test the ages assigned to these four groups. Dating of the French Village Quartz Diorite is in progress to determine whether or not this intrusion, on the basis of field relations the oldest in the Saint John area other than the orthogneissic units in the Brookville Gneiss, is indeed ca. 560 Ma or younger. Dating of a gabbroic pluton (Duck Lake and/or Mechanic Settlement) is planned for 1991 work. Mapping will be extended to include plutons in the eastern Caledonian Highlands (Figure 34), and comparisons will also be made to plutons west of the Saint John River (Dickson 1983; Currie 1987).

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QUATERNARY GEOLOGY AND GEOCHEMISTRY OF TILLS IN THE BIG BALD MOUNTAIN AND SERPENTINE LAKE AREAS, VICTORIA AND NORTHUMBERLAND COUNTIES, NEW BRUNSWICK*

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The purpose of this project is to produce two surficial geology maps (NTS 21 O/1, 21 O/2) at a scale of 1:50 000 and to obtain detailed data on till geochemistry and provenance in these areas. Field work was initiated during the summer of 1990 and production of the final report is planned for the end of 1994. The first part of the final report will include a description of surficial materials and will present a paleogeographic interpretation of Quaternary events. The second part will present and discuss till provenance data, with emphasis on geochemical anomalies.

Le but de ce projet est de cartographier les formations en surface à l'échelle du 1/50 000 et d'obtenir des informations détaillées sur la géochimie et la provenance des tills dans la région (SNRC 21 O/1, 21 O/2). Les travaux de terrain ont débuté à l'été 1990 et la remise du rapport final est prévue en décembre 1994. La première partie du rapport comprendra la description des sédiments en surface et une interprétation paléogéographique des événements quaternaires. Dans la seconde partie, la provenance du till sera déterminée en mettant l'accent sur les anomalies géochimiques décelées.

The study area is mainly located in the Miramichi Tectonostratigraphic Zone and is underlain by Cambro-Ordovician metasediments and metavolcanics of the Tetagouche Group, as well as by Ordovician and Devonian granitic and gabbroic intrusions. Devonian sedimentary and volcanic rocks of the Dalhousie Group of the Tobique-Chaleur Zone occur in the western part of the area. There are known mineral occurrences in the region (Cu, Pb, Zn, Ag, Bi and U) and field investigations are currently being conducted by private companies and public agencies.

The first part of this project consists of surficial geology mapping at a scale of 1:50 000. The accompanying report will describe Quaternary sediments, discuss modern geologic processes, and present data relative to land-use planning, aggregate resources, and terrain sensitivity to

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*Contribution to the Canada New Brunswick Cooperation Agreement on Mineral Development, 1990-95. Project carried by the Geological Survey of Canada.

environmental stress. The second part will consist of a detailed study of till geochemistry and provenance. Geochemical analyses will be carried out on the -0.063 mm fraction (silt and clay) and results will be presented for gold and thirty-three other elements.

In the course of previous work (Lamothe 1990; Fyffe and Pronk 1984), 652 till samples have been analysed. One objective of this project is to complete the sampling grid in order to upgrade it to at least 1 sample site per 4 km^2. Approximately 251 samples will be required.

Some 90 till samples were collected during the 1990 field season. However, much of the field work consisted of logging stratigraphic sections and measuring glacial erosion marks (striae, rattails, etc.). This work will also include detailed aerial photograph interpretation and sedimentological analyses. This project, consisting of geological maps and an accompanying report, will complement previous reports (Gauthier 1982, 1983; Rampton et al. 1984) by providing more detailed information.

Till sampling will continue in 1991-1992 and the analytical results will be combined to existing data sets in order to produce geochemical maps. Observations and interpretations from the first part of the study will enable us to determine ice-flow directions and the provenance of till components. Particular emphasis will be placed on establishing dispersal patterns of geochemical anomalies and on determining the source areas of these anomalies.

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STRUCTURAL CONTROLS ON GOLD MINERALIZATION IN NEW BRUNSWICK: PRELIMINARY RESULTS*

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Ste-Foy, Québec G1V 4C7

Structural characteristics of gold occurrences have been studied in detail along the Elmtree and Rocky Brook-Millstream fault zones in northeastern New Brunswick. The Elmtree deposit and country rocks display evidence of both subhorizontal and subvertical tectonic movements and a contractional duplex geometry related to the Elmtree fault is inferred. Gold showings along the Rocky Brook-Millstream Fault Zone occur in various structural settings which are associated with a regional dextral movement along the fault zone.

Dans le nord-est du Nouveau-Brunswick, les caractéristiques structurales de plusieurs indices aurifères situés en bordure des failles d'Elmtree et de Rocky brook-Millstream ont été étudiées. Le dépôt d'Elmtree et les roches encaissantes montrent des évidences de mouvements tectoniques sub-horizontaux et sub-verticaux. Une géométrie de duplex en compression associé à la faille d'Elmtree est proposée. Les indices d'or situés en bordure de la faille de Rocky brook-Millstream sont associés à différents pièges structuraux cadrant parfaitement avec un décrochement dextre le long de la zone de faille.

During the summer of 1990, a Canada-New Brunswick Cooperation Agreement on Mineral Development (MDA II: 1990-95) project on structural controls of gold mineralization was initiated in New Brunswick. This project is part of a larger scale study of gold deposits in the Canadian Appalachians (Dubé 1990). Gold occurrences are known along the Elmtree and Rocky Brook-Millstream fault zones in northeastern New Brunswick (Ruitenberg et al. 1990). Studies during the 1990 field season were concentrated on the Elmtree deposit, occurring along the Elmtree fault, and on the Stephen-Lavigne-Bradley brooks and Rocky Brook shaft showings along the Rocky Brook-Millstream Fault Zone.

The Elmtree deposit, held by Corona Corporation, is hosted by an altered and mineralized differentiated gabbroic sill occurring within the black slates and phyllites of the Elmtree Group along the Elmtree fault. This major structure is

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*Contribution to the Canada New Brunswick Cooperation Agreement on Mineral Development, 1990-95. Project carried by the Geological Survey of Canada.

interpreted as a faulted unconformity between the Ordovician Elmtree Group to the northwest and the Silurian Chaleur Group to the southeast. The main auriferous zone, known as the West Gabbro Zone (WGZ) (McCutcheon et al. 1988) has been mapped in detail. Paktunc and Ketchum (1989) suggested that the highest gold mineralization is associated with narrow dextrally sheared and altered zones anastamosing around relatively undeformed lenses of rocks.

Although strong evidence indicating a dextral movement was found along the Elmtree fault in the Corona property, the geometrical relationships of shears, quartz veins, and fractures in the WGZ do not perfectly fit a horizontal shear model. At the WGZ, two types of shear zones have been recognized: high-strain shear zones and medium-strain shear zones. High-strain shear zones appear as the northern and southern limits of the exposed part of the mafic body. To the north, these zones record a dextral sense of shear but the southern zones do not show clear kinematic indicators. High-strain shear zones are frequently associated with dismembered quartz veins. The medium-strain shear zones occur between the high-strain zones and form the anastomosing pattern recognized by Paktunc and Ketchum (1989). They isolate lensoid regions of weakly deformed and undeformed gabbroic rocks and are associated with sheared quartz veins (central and oblique shear veins). Shear veins are frequently striated and all striations record a down-dip or steeply plunging tectonic vector indicating the dominance of an upward movement along these shear zones. Also, both subvertical and subhorizontal extension veins and fractures can be seen at the WGZ and suggest a complex combination of horizontal and vertical tectonic flow. Ore minerals (arsenopyrite, pyrite, and pyrrhotite) are concentrated along both type of shear zones in foliation-parallel veinlets and also in high-angle veinlets and fractures. The intensely sheared and altered zones carry the highest concentration of gold (Hoy 1987). The structural pattern of shears and veins at the WGZ can be explained by a contractional duplex geometry (Woodcock and Fisher 1986) associated with the Elmtree fault. Down-dip stretching lineations within pebble conglomerate of the Chaleur Group at the Discovery Zone (1.5 km east of WGZ) also suggest a local upward component along the Elmtree fault.

The Rocky Brook-Millstream Fault Zone (RBMFZ) has been defined as a major dextral wrench fault at the contact between the Elmtree and Miramichi terranes (Ruitenberg et al. 1990). In the Bathurst area, it separates the Chaleurs Group to the northwest from the Ordovician Tetagouche Group to the southeast. The RBMFZ has been divided into a main break and a south branch zones (Philpott 1987). Tectonic slices of serpentinite and serpentinite breccias occur within the main break along which are located the Stephens-Lavigne-Bradley Brooks gold showings. The Rocky Brook shaft deposit (Philpott 1987) contains Zn-Pb-Au mineralization occurring along the south

branch of the RBMFZ. These showings have been classified as quartz-carbonate and massive polymetallic vein-types occurrences (Ruitenberg et al. 1990).

The Stephens Brook showing is the best exposed occurrence along the main break. The ore zone is associated with a north-south-trending sinistral shear interpreted as an antithetic splay of the main break. Gold mineralization is associated with massive and semi-massive shear veins of arsenopyrite. Semi-massive sulphide concentrations are also found as a matrix in the fault gouges or shear-related stockwork in the host rocks. Shear-related metre-wide mineralized quartz veins are also found in the Stephens Brook area. At Lavigne Brook, the mineralization is associated with WSW-ENE-trending dextral shears and related NW-SE synthetic shears. The ore mineralogy is slightly different from the Stephens Brook area and consists of pyrite-chalcopyrite-sphalerite. Local occurrences of garnet within host rocks and skarns suggest a possible magmatic source of ore fluids that could have originated from the Devonian Nicholas Dénys pluton (Fyffe et al. 1981). Field work on the Bradley Brook showing indicates that the mineralization is concentrated along NW-SE trending extension veins of arsenopyrite-galena-quartz. All the showings visited along the main break fit with a dextral movement along the RBMFZ. The ore fluids were trapped in various settings related to splays along the main fault zone.

Well-exposed sulphide-rich mineralization can be seen at the Rocky Brook shaft deposit, which has been used to document the type of mineralization and the kinematics of the south branch of the RBMFZ. At this site, sulphide-rich zones (sphalerite-galena-pyrite) are associated with WSW-ENE trending dextral shear zones and related synthetic shears. High-angle antithetic sinistral shears locally join or displace the main mineralized shear zone. The wall-rock alteration is minimal and the ore geometry consists of foliation-parallel massive sulphide veins and semi-massive to dissiminated mineralization along the shear zones.

A preliminary examination of gold occurrences in northeastern New Brunswick indicates that all examined auriferous mineralization belong to the structurally-controlled mesothermal vein type according to Dubé's (1990) classification. Like the Stog'er tight prospect (Dubé 1990), the Elmtree deposit belongs to the altered wallrock sub-type. Gold mineralization is concentrated along, and controlled by, brittle-ductile to brittle shears and fault zones resulting from a dextral transpressive faulting event along the RBMFZ and related faults (van Staal and Fyffe, in press).

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PART III

UNIVERSITY OF NEW BRUNSWICK

REPORT OF ACTIVITY, DEPARTMENT OF GEOLOGY AND GEOLOGICAL ENGINEERING PROGRAM, UNIVERSITY OF NEW BRUNSWICK

H.W. van de Poll
Chairman of the Department of Geology

GENERAL

The Department comprises 15 full-time Faculty, 3 Post-doctoral Fellows, 1 Professor Emeritus, 1 Research Associate, 7 Technical Staff, 3 Secretarial Staff, 6 full-time, and 2 non-resident PhD candidates; 12 full-time, and 2 non-resident MSc students; 68 Undergraduate Students (26 science majors in geology and 42 geological engineers). The Natural Sciences and Engineering Research Council supported the Department's on-going research projects in the amount of $239 400. In addition, the Department was successful in obtaining a major research and development grant from the N.B. Department of Commerce and Technology in August, 1990. The sum of $380 501 was awarded for the purchase and operation of a CARIS workstation. Other financial partners in the CARIS venture are the University of New Brunswick ($87 855, mainly in kind), Potash Company of America ($20 000) and Universal Systems Ltd. ($39 460). The new computer hardware (a SUN station, etc.) has recently been installed. The equipment is located at the Department of Geology. The Maritime Provinces Higher Education Commission provided $97 258 for research equipment during 1989-90 ($49 950 toward the purchase of ten new research/ teaching microscopes). Research contracts for varying periods were negotiated, including various projects with the Geological Survey of Canada ($127 332), Energy, Mines and Resources Canada ($14 677), Lithoprobe ($20 000/ann.), Shell ($14 000, two-year funding), Brunswick Mining & Smelting ($19 000/ann. for two years), and smaller amounts from the University of New Brunswick Research Fund ($6600), Chevron ($500), AMOCO Canada Petroleum Company Ltd. ($1500), Challenge '90 ($4622), and others.

Six geologists and ten geological engineers have graduated from UNB since our last report. One PhD and two MSc degrees were awarded at Encaenia. Ms. Lori Kennedy (MSc candidate) was presented with the Best Student paper award (Physical Sciences) by the Microscopical Society of Canada at the annual meeting in Halifax. Mr. Wyn Roberts (MSc graduate) received the CIM award for the best MSc thesis in Canada dealing with an economic subject at the annual meeting in Ottawa. Mr. Shoufa Lin and David Keighley were this years recipients of the W.J. Wright Fellowship. The GAC/MAC Fredericton '85 prize recipient this year was Mr. Christopher D. Hawkes. Mr. Robert MacNaughton was awarded the CSPG 'AUGC Best Student Presentation' (Nov., 1989 AUGC meeting) and the Atlantic Geoscience Society 'Rupert McNeil Award', for best student presentation in January, 1990. John Currie and Chris Hawkes were awarded Canadian Society of Exploration Geophysicists Scholarships and John Currie also

received an undergraduate scholarship in geophysics from AMOCO Canada Ltd.

Drs. P. Stringer and D.J. Bachinski are presently on a one-year sabbatical leave. Their teaching duties are being handled by other members of faculty with the assistance of Drs. L.B. Goodwin, H.H. Hassan, A.F. Park, and Mr. D. Keighley.

All of our undergraduate students were able to obtain full-time employment this past summer. Several of our students worked on projects in New Brunswick (i.e., NBDNRE, Brunswick Mining & Smelting, Heath Steele Mines, and other private organizations). Members of the faculty and graduate students published some 50 scientific papers and presented about 25 papers at various regional, national and/or international meetings. In addition to attending and presenting talks at other meetings, members of the Department are involved in the organization of the Canadian Tectonics Group meeting (October 19-21, 1990) and the Bailey Geological and Geological Engineering societies are organizing the annual Atlantic Universities Geological Conference (November 1-4, 1990) for undergraduate students. Both the N.B. Department of Natural Resources and Energy and the local branch of the CIM are actively assisting the students in the final preparations for this conference.

As previously reported, the Department of Geology has initiated two major projects in support of geological research and mineral development: 1) Chair in Economic Geology; and 2) Applied GIS (Geographic Information System) research in geoscience. Following consultation with the Natural Sciences and Engineering Research Council, the above two initiatives have been combined into a Senior and Junior **Chair in Economic Geology and Applied Geomatics** with the following broad mandate.

> "To expand the research base in Economic Geology in New Brunswick and to assist the Canadian mineral industry, government agencies and the geological community in adopting GIS technology for improved earth science data management and information extraction (geomatics)".

The individuals occupying the Chair will be expected to conduct research in problems specific to the mineral resources sector and encourage members of the Geology Department in fields of expertise other than Economic Geology, to participate in projects of economic interest. The Chair will also facilitate the education and training of students interested in mineral resources, and contribute to the rapidly expanding Geological Engineering program.

Economic geology research could include, but would not be restricted to:

1) detailed structural analyses of base-metal sulphide host-strata in poly-deformed terranes,
2) gold metallogenesis in ophiolite suites,
3) syn-sedimentary metallogenesis in post-orogenic molasse basins,
4) fluid-inclusion studies in mineral exploration,
5) polymetallic tin-tungsten mineralization and late-stage orogenic granitic intrusions,
6) lithogeochemistry as a guide to base-metal mineralization.
7) Late Triassic rifting, northwest-trending faults, and gold-pyrite mineralization,
8) rare-metals distribution in the Canadian Appalachians,
9) trace-element studies of volcanogenic sequences,
10) volcanology of mineralized extrusive sequences.

In addition to the economic geology objectives mentioned above, the Chair will also be concerned with the adaption and expansion of existing CARIS software for earth science applications. It should:

1) expand CARIS-based geomatic research in support of mineral exploration and geological mapping;
2) address current limitations to, and inefficiencies in, earth science data handling and manipulation;
3) improve the extractive value of existing and future geoscientific data, in particular data acquired by advanced technology, thereby improving mineral exploration and mining efficiency vital to the future of the mining industry of Canada;
4) down-size CARIS for individual mine and field-project use.

Additional benefits of these activities to the geological community include:

1) expansion of the existing research capability at the University of New Brunswick in fields of applied geology; and
2) expanded research, training and educational opportunities to students who are oriented toward digital geological mapping and computer-assisted data management and manipulation.

The long-term viability of the mineral industry in Canada is dependent on the ability to find and develop new ore bodies, often at greater depth than those presently being mined. Success will depend on new and better exploration techniques, a higher level of geological expertise, and on improved interpretations from existing data. The proposed Chair in Economic Geology and Applied Geomatics is designed to contribute to that objective.

The total estimated budget for the operation of the Chair over the initial five-year period is in excess of 1.5 million or approximately $313 000 per year excluding funds for individual research projects.

The Department of Geology has nearly reached its fund raising objectives with pledges from industry to obtain the necessary matching funds from NSERC. A most critical development in the Chair objective was the approval of a grant application made to the New Brunswick Department of Commerce and Technology for a CARIS Workstation. The application which has recently been approved includes funding over a two-year period for all the computer hardware, software, maintenance, operating and manpower costs related to development work on CARIS.

Geological Engineering:

Geological Engineering continues to be a popular program at UNB with approximately 42 undergraduates enrolled in all years. Ten students graduated from Geological Engineering this year and 12 new students entered the five-year programme at various levels from year one to year three. Almost every student from first year on was employed in geological work over the summer and this in itself is expected to have a positive impact on future enrolment in the program.

This year, Dr. A. Valsangkar of the Department of Civil Engineering is replacing Dr. B.E. Broster as the Director of Geological Engineering.

Geochemistry:

Dr. N.J. Susak is back from his sabbatical leave at the Chemistry Division of Oak Ridge National Laboratory, Oak Ridge, Tennessee, U.S.A., where he was conducting spectrophotometric and potentiometric studies of hydrothermal solutions in collaboration with Drs. D.A. Palmer and D. Wesolowski. Spectrophotometric studies of Cr(VI) were undertaken to determine the stability of chrome-chloride complexes and to investigate the possibility of using chromate as a colorimetric pH indicator in oxidizing-acid solutions. Work was started to determine the hydrolysis and chloride complex stability constants for Mo(VI) by potentiometric titration. This study (in conjunction with the previous studies of Cr(VI) and W(VI) by the staff at Oak Ridge National Laboratory) will provide the first complete determination of high-temperature stability constants of a chemical group and should provide valuable insights into the general behaviour of elements in hydrothermal solutions. Complementary spectrophotometric studies of Mo(VI) complexes will be conducted at U.N.B. Spectrophotometric determinations of nickel complexing will also be initiated. Work on the hydrothermal solubility of cobalt oxides and sulphides is continuing.

Geophysics:

Drs. K.B.S. Burke, H.H. Hassan, and J. Andersen completed an investigation of the historical seismicity of northern and eastern New Brunswick for the periods 1826 to 1866 and 1944 to 1961 in a contract study sponsored by the Geophysics Division of the Geological Survey of Canada. Three previously unlisted events were found and evidence was also found for significant changes to present listings of earthquake locations, times and magnitudes in the Canadian Earthquake Epicentre File. The study showed that the Central Highlands has been a region of continuing earthquake activity for the past 165 years.

Mr. G.A. Allcott completed his thesis on the geophysical tracing of contacts in the Heath Steele Mines area. He found that detailed VLF and magnetic measurements could be used to map steeply dipping contacts between polydeformed chlorite tuff and felsic volcanic rocks. Quantitative interpretation of data was based on computer modelling of magnetic profiles.

Glacial Geology:

Dr. B.E. Broster's research has focused upon applications of glacial processes and products relative to engineering, environmental, and exploration activities. This year, research was completed on two studies of glacigenic deformation; one in New Brunswick with Dr. A.A. Seaman of NBDNRE on glacial thrusting of weathered granite, and another study on soft-sediment deformation in British Columbia. Research on neotectonics at Saint John, New Brunswick, with Dr. K.B.S. Burke was completed and an article is now in press with Atlantic Geology.

Mr. Chris Bianchi completed his BSc thesis project on Till Geochemistry at the Mount Pleasant Caldera, New Brunswick, and Ms. Solweig Balzer started a MSc project on glacial dispersion and stratigraphy of the Canterbury map area as part of NBDNRE regional mapping projects conducted by Dr. Seaman.

Mineral Deposits:

Economic geology activity continued to be focused mainly on Appalachian mineral deposits with an emphasis on massive sulphides.

Dr. D.J. Bachinski continues his on-going studies on porphyry coppers. Dr. P.F. Williams and Mr. W. Roberts (recent MSc graduate) completed a study of the structure of the potash in the Dennison Mine at Sussex as an aid to mine safety and improved economic assessment of its potash potential.

Dr. J.P.A. Noble, with PhD graduate student Mr. Ali Chowdhury, are continuing their projects on the diagenesis and fluid history of the Albert Formation in the Moncton basin. Several publications relevant to future oil and gas exploration in New Brunswick are in preparation and follow-up studies are in the planning stage. Mr. Clint St. Peter, MSc candidate

under the supervision of Dr. Noble, is studying lithologic and seismic facies of the Albert Formation for a better understanding of the structural evolution, trap potential, and subsurface distribution of the oil-bearing Albert Formation.

Palaeontology:

Dr. A. Logan is continuing actuopalaeontological studies of modern hard substrate communities in the Bay of Fundy with a view to ascertaining their value for palaeoecological reconstruction in the Mesozoic. Following completion of his project on competitive interactions of hermatypic corals in Bermuda, Dr. Logan has commenced a new NSERC-supported study on growth rates of two species of hermatypic corals from Bermuda and Barbados. The purpose of this study is to determine the effects of depth and latitude on the growth rates of these corals as an aid in palaeoecological and palaeoclimatic determinations.

Dr. R.K. Pickerill is continuing work on the structure, composition, ecology, and evolution of Silurian brachiopod-dominated communities of Arisaig (Nova Scotia). Additionally, he is making a study of the structure, composition, and evolution of Ordovician marine benthic communities in Quebec with Dr. T.L. Harland and in Wales with Dr. P.J. Brenchley. He is also collaborating with Dr. M. Wade of the Queensland Museum, Australia in a study of Cambrian jellyfish from the Saint John area. He continues his extensive trace-fossil research in Spain, Portugal, Quebec, Newfoundland, New Brunswick, Alaska, Oregon, southern California, and northern Greenland. Mr. D. Fillion, one of his PhD graduate students, is in the final stages of his studies in Oregon and southern California.

Igneous Petrology:

During 1989/90, the Igneous Petrology group included Dr. J.T. Dunn and two graduate students (Mrs. Suporn Intasopa - MSc candidate and Mr. Cuneyt Sen - PhD candidate). Group activities during the year included analytical, experimental, and field-based research in various areas of Igneous Petrology and Geochronology.

Dr. Dunn completed the revisions for three papers submitted during summer 1989. Papers on the Petrology and Petrogenesis of the Ministers Island dike (Dunn and Stringer 1990), the Diffusion of Ferrous Iron in Peraluminous Silicate Melts (Dunn and Ratliffe 1990), and the Fabrication of an Automated Oxygen Fugacity Controller for High-Temperature Furnaces (Dunn 1990) were published in Contributions to Mineralogy and Petrology, The Journal of Geophysical Research, and the American Mineralogist, respectively.

Dr. Dunn and Mr. Sen completed work on the detailed trace-element geochemistry of the minerals and their host lavas from Mt. Adams (Washington, USA). That project involved the

separation of minerals from a suite of volcanic rocks from Mt. Adams. The separated minerals were analysed for major elements by electron microprobe and for trace elements by ICP-MS (digested samples were sent to MUN) and ion microprobe (in collaboration with Dr. N. Shimizu of the Woods Hole Oceanographic Institute). The results were used to determine a complete new set of trace-element mineral/matrix partition coefficients for olivine, orthopyroxene, and plagioclase in volcanic rocks ranging in composition from Alkali olivine basalt to silicic andesite. In addition, Dr. Dunn determined that the augites in the Mt. Adams volcanics were nearly all xenocrysts from two different sources (lower crustal two-pyroxene granulites and metasomatized spinel lherzolite mantle). The study resulted in two papers that have been submitted to the journals Geochimica et Cosmochimica Acta and Contributions to Mineralogy and Petrology. Dr. Dunn and Mr. Sen also presented two papers on this work at the 1990 American Geophysical Union Spring Meeting in Baltimore USA (Dunn and Sen 1990; Sen and Dunn 1990). In addition, the trace-element studies of olivine phenocryst/matrix pairs yielded anomalously high Ta partition coefficients (approximately 0.08 to 0.10). Those results led to an experimental study of the partitioning of La, Ta, and Nb between olivine and basaltic to boninitic magmas in order to see if the mineral/matrix results could be reproduced experimentally. That study is being done in collaboration with Dr. A.J. Irving of the University of Washington, who is analysing the experimental products.

Dr. Dunn and Mrs. Intasopa have continued to work on the Central Thailand Volcanic belt. During the past year, Dr. Dunn visited the field area in central Thailand. Samples were collected primarily for $^{40}Ar/^{39}Ar$ dating. Nine new dates were determined in collaboration with Dr. D.R. Lux at the University of Maine. In addition, Mrs. Intasopa completed the Sr isotope analysis of 12 samples from the northern part of the Central Thailand Volcanic Belt. Those results were used to generate two Rb/Sr isochron ages and a new model age for the western margin of the Indochina cratonic block. The results of this study have contributed to a significant revision in the understanding of the tectonic history of the Indochina-sinoburmalaya cratonic suture. Mrs. Intasopa and Dr. Dunn presented the results of the Rb/Sr isotopic work at the 1990 Spring American Geophysical Union Meeting in Baltimore USA (Intasopa and Dunn 1990) and Mrs. Intasopa, Dr. Dunn, and Dr. D.R. Lux (Univ. of Maine) will present the results of the $^{40}Ar/^{39}Ar$ dating study at the 1990 Fall American Geophysical Union Meeting in San Francisco, USA (Intasopa et al. 1990).

Dr. Dunn has continued to upgrade his laboratory facilities by building a piston-cylinder high-pressure apparatus (with the assistance of a $37 000 NSERC equipment grant) and by installing an ARL electron microprobe. Both instruments are nearly complete and should be in regular use by late Fall 1990.

Metamorphic Petrology:

Dr. J.G. Spray is continuing his investigations of metamorphism and melting in fault and shear zones and on the generation and evolution of ophiolite complexes. The work on ophiolites has focused on dynamothermal processes occurring in both the mantle (Spray 1989a) and the crust (Flagler and Spray, in press), based on Appalachian/Caledonian bodies. Experimental work has focused on the application of friction welding apparatus to the study of frictional heat phenomena in rock. The equipment enables fault movement to be simulated in terms of velocity, load (stress), and duration. Different fault rocks can be produced by this process (e.g., gouge at low power and melt at high power). The experimental technique has considerable potential for providing insight into fault dynamics and the generation of earthquakes. Ms. Lori Kennedy is completing her MSc project on the high-temperature alteration of rock by diamond drag cutters as part of the rock friction program funded by Shell Canada Ltd.

Two new graduate students, Jeff Bellen and Gordon Clarke, will be starting on MSc/PhD projects related to metamorphic/metasomatic effects associated with the Brunswick No. 12 base-metal orebody and the new intersection near Bathurst.

Mineralogy/Crystallography:

Dr. L.T. Trembath has been studying crystallization of feldspar in synthetic and natural systems in order to develop a better understanding of the crystallization and emplacement of granitoids.

Regional Mapping Projects:

Several members of the Department continue to be active in regional studies. Dr. R.K. Pickerill, in collaboration with Dr. K.L. Currie of the Geological Survey of Canada, and Dr. D. Nance of the University of Ohio, is involved in regional mapping in the Saint John area (New Brunswick). Professor I.M. Patel is working on the Precambrian-Cambrian boundary in New Brunswick. Dr. J.P.A. Noble is continuing his regional stratigraphic studies of the Silurian-Devonian of northern New Brunswick, while the Acadian cleavage in mainly Siluro-Devonian rocks in southwestern New Brunswick and adjacent Maine and the structure of the Upper Devonian Perry Formation are being investigated by Dr. P. Stringer. The structure and extent of the Ministers Island dyke in southwestern New Brunswick and eastern Maine, and the mainland and offshore structure of the Lepreau Formation in southern New Brunswick, are being investigated by Drs. Stringer and Burke.

Dr. H.W. van de Poll continues his interest in applying specialized mapping techniques in his study of the Permo-Carboniferous of New Brunswick and Prince Edward Island emphasizing the lithostratigraphy, sedimentology, and physical diagenesis of these strata for an overall analysis of the palaeogeographic paleoclimatic and structural evolution of the Maritimes Basin during late Paleozoic time.

Postgraduate students working under Dr. Williams' direction continue mapping in the Dunnage Zone around eastern Notre Dame Bay (Newfoundland), in Cape Breton Island, the Northwest Territories, and in the vicinity of Thompson Mine, Manitoba.

Sedimentology:

Dr. J.P.A. Noble is continuing his long-range sedimentological studies emphasizing the diagenesis and burial histories of the Silurian-Devonian basins in northern New Brunswick and the Gaspé. In particular, comparisons of diagenesis in the basins and adjacent shelf borders are shedding light on the structural and burial histories of these marginal zones. A similar, but much better exposed (and much better known stratigraphically) foreland basin in the Alps, is now being studied for the information it provides on the less well known Appalachian basins.

Dr. R.K. Pickerill, in addition to contributing sedimentological work to a regional study of the Saint John Group, is also continuing his extensive studies of Middle Ordovician sedimentation of the Trenton Group carbonates of Quebec. Two of his graduate students are involved in sedimentological studies in the Carboniferous of Cape Breton and Lower Devonian of central New Brunswick.

In addition to applying specialized sedimentological mapping techniques for regional Basin analysis, Dr. H.W. van de Poll and Professor I.M. Patel are continuing their studies on physical diagenesis. These studies concentrate on post-depositional processes related to compaction of the sediments. Their findings suggest that many sedimentary features, including grain-matrix and clastic ratios and certain types of sedimentary structures may not entirely be the result of primary processes, but may also be attributed to secondary processes of sediment remobilization during compaction. This work is on-going in conjunction with Carboniferous Basin analysis and has potential applications in facies analysis, palaeoseismic interpretations, syndepositional tectonics, and petroleum reservoir studies.

Structural Geology:

Dr. J.C. White has concentrated on establishing the deformation geometry and mechanical history within part of the Parry Sound shear zone. The geometric interpretation in turn has been used to establish a framework for detailed micro-mechanical studies of deep crustal deformation, particularly strain localization processes within the shear zone. On-going studies include deformation within the Cobequid Fault Zone and the relationship to transitional anelastic-seismic behaviour. The newly installed analytical SEM/TEM facilities now make possible a long postponed study of extremely fine-grained, polymineralic rocks deformed under extreme seismic release with subsequent aseismic deformation. Determination of the conditions of deformation may allow correlation with intraplate seismic activity characteristic of the Saguenay, Quebec earthquake (1988).

Dr. P.F. Williams and his students are working on major faults in Atlantic Canada including the Dover Fault, Newfoundland with Mr. A. Caron, faults in southern New Brunswick with former student Mr. A. Leger, the Chanceport-Lukes Arm Fault system in Newfoundland with Mr. B. Lafrance, and the Indian Islands Faults, Newfoundland with Dr. J. Urai. The objective of these studies is to synthesize the Appalachian ductile and brittle faulting history as a basis of understanding, among other things, its influence on Carboniferous sedimentation and emplacement of quartz and calcite veins, many of which are related to the faults.

Research by Post-doctoral Fellow, Dr. Laurel Goodwin, conducted under the auspices of Dr. P.F. Williams, is focused on an analysis of the structural evolution of tectonic boundaries in the Newfoundland Appalachians, with particular emphasis on the Baie Verte and Grubline areas. Funding is provided through Lithoprobe. The main goal of the project is to provide geologic constraints on interpretations of seismic data obtained from the Lithoprobe East Transect. Additional objectives include a study of the structural behaviour of terrane boundaries over time and an investigation of inhomogeneous deformation of anisotropic materials.

The study of the structural implications of shear zones in the Shelburne, Nova Scotia area by Dr. S.J. Hwang has been completed and a copy of Dr. Hwang's thesis has been delivered to the Nova Scotia Department of Mines and Energy. Dr. Hwang's PhD project was jointly supervised and financed by Drs. P.F. Williams (UNB) and J.D. Keppie (N.S. Dept. of Mines). Another PhD graduate student, Shoufa Lin, is continuing his structural project in the Cape Breton Highlands. In addition, Dr. Williams is involved in a project at the Thompson Nickel Mine, Manitoba with Dr. C. van Staal and Mr. W. Bleeker.

Dr. P.F. Williams is involved in three joint projects with the Geological Survey of Canada. Graduate students Christopher Beaumont-Smith (PhD) and Robin Wyllie (MSc) are conducting structural mapping around the Back River Complex and the Archaean rocks of the Bathurst Inlet area (NWT), respectively. GSC supervisors are Maurice Lambert and Jack Henderson, while Robin Wyllie's project also receives industrial funding.

The mapping project [supervised by Dr. P.F. Williams (UNB) and Dr. S. Tella (GSC)] in the Tavani area (Keewatin, N.W.T.), involving two post-doctoral fellows, Drs. A. Park and S. Ralser, was completed in August. This project involved detailed stratigraphic and structural mapping coupled with geochemistry and geochronology of a portion of the Darhwin-Ennada greenstone belt. The final report of this project has been submitted and will be published as a Geological Survey of Canada Special Paper and an "A" series, 1:100 000 map.

Dr. P.F. Williams and Mr. B. MacEachen have continued developing a field-based computerized mapping system using Versacad; this is being interfaced with CARIS. The system enables efficient production of field slips at any scale and input of all collected map data into a digital file in the field.

Dr. Williams is also conducting computer simulation experiments on the development of folds during shear straining.

Neotectonics:

Drs. K.S.B. Burke and P. Stringer are continuing an investigation of potentially neotectonic features in southwestern New Brunswick under a research agreement with Energy, Mines and Resources. Marine geophysical data have been evaluated in terms of neotectonic features in Passamaquoddy Bay and interpretation has commenced of marine geophysical data offshore from Point Lepreau and Campobello Island.

Deformation Studies:

Members of the Centre for Deformation Studies in the Earth Sciences (Broster, Burke, Spray, Stringer, van de Poll, White, Williams) have supported an array of research projects over the last year including a significant number of meeting presentations (see reports by individuals and publication list). In addition, the Centre is sponsoring the 10th Annual Canadian Tectonics Group Workshop in Liscombe, Nova Scotia, partly in recognition of the founding workshop held at Fredericton in 1981; and Dr. John G. Spray has organized a Special Session on Friction Phenomena at the Dallas Geological Society of America meeting. Dr. Bruce E. Broster is currently President of the Canadian Quaternary Association (CANQUA) and will be organizing and hosting the biennial symposium at UNB in June, 1991.

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PART IV

RESEARCH AND PRODUCTIVITY COUNCIL

MINERALOGY AND PROCESSING AT THE NEW BRUNSWICK RESEARCH AND PRODUCTIVITY COUNCIL

Compiled by Dave Desjardins

INTRODUCTION

The Research and Productivity Council (RPC) is a multidisciplinary science and engineering organization that offers its services on a fee-for-service basis to industry and government. Mineral-related activities are directed primarily in the disciplines of petrology, mineralogy, lithogeochemistry, mineral analysis, and mineral processing. RPC offers a wide range of expertise in these disciplines through its staff of electrochemists, chemists, and engineers. The activities during the past year in Mineralogy and Processing are outlined below:

MINERALOGY

The activities in the mineralogy group have been concentrated in the following three major areas:

(1) Electron microprobe and image analysis applications for mineralogical studies of geological and metallurgical samples and for deteriorated concretes;
(2) Petrographic analysis and geological interpretation of petrographic data; and
(3) Geological expertise applied to crushed aggregate quarry developments in southeastern New Brunswick.

In addition to the above, small electron microscope studies were carried out for a large number of clients both internal and external.

PROCESSING

Both hydrometallurgical and roasting projects have been carried out in the past year. Highlights of these projects are:

(1) Development of a ferric chloride leaching flowsheet; and
(2) Assessment of temperature effects on a gold cyanidation flowsheet.

Capital investment by ACOA has enabled the group to provide unique mineral processing options in the area of gas clean-up for the mineral industry. This has been accomplished by a high-temperature filtration test unit for particulate removal and improved by-product uses. This technology base will strengthen the services available to industry.

The group has also upgraded its ability in materials processing and has equipped an extensive array of equipment in its crusher house for crushing and sizing a wide variety of materials.